AUG 2 3 1943


# The Engineer

VOL. CLXXVI—No. 4569 | 28, ESSEX ST., STRAND, LONDON, W.C.2 | AUGUST 6, 1943

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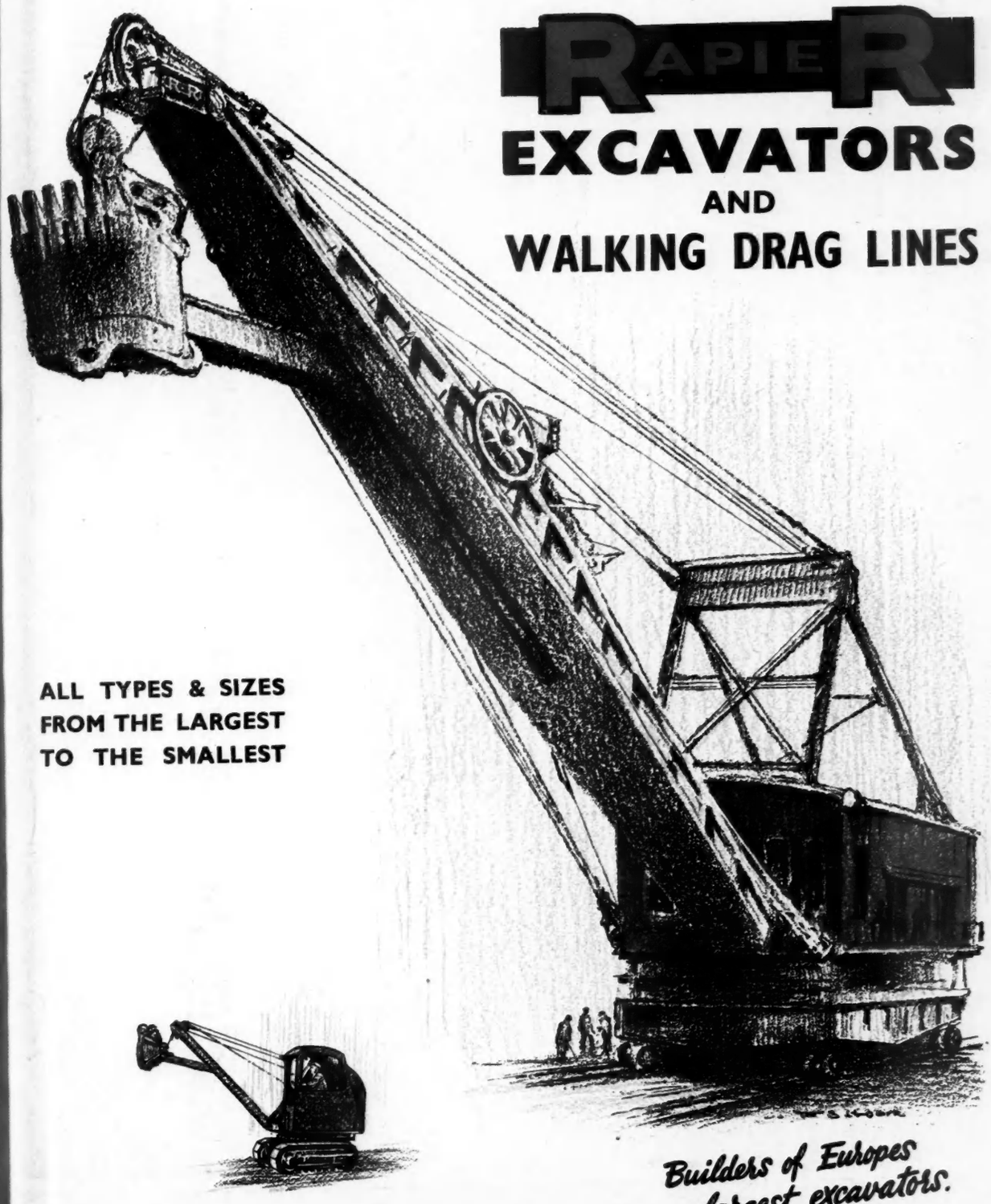

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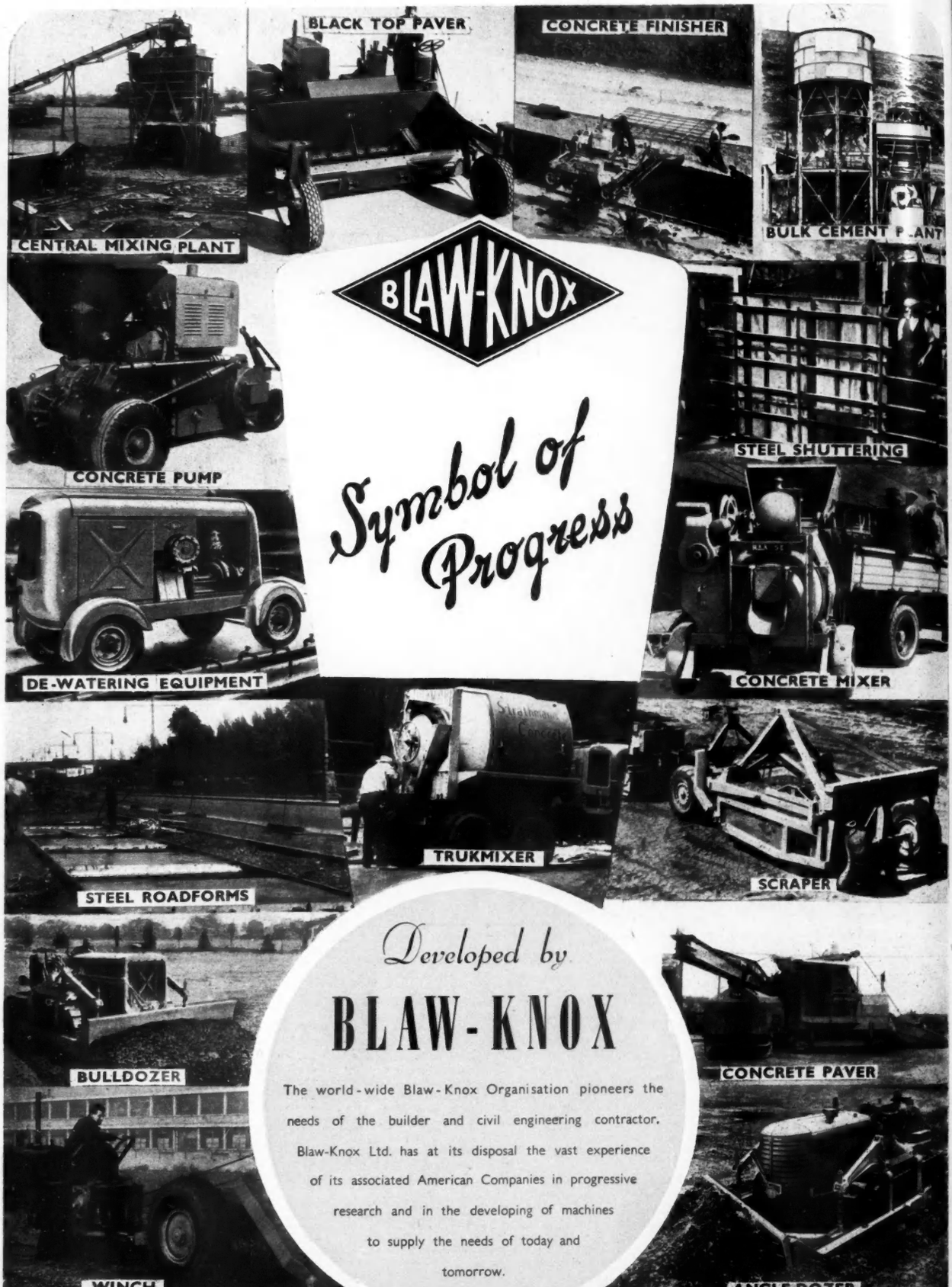
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# The Engineer

LONDON, FRIDAY, AUGUST 6, 1943.


## PUBLIC NOTICES

**TY BOROUGH OF BRIGHTON**

**LECTRICITY UNDERTAKING**

**OINTMENT OF POWER STATION SUPERINTENDENT**

**lications are Invited for** the POSITION of POWER STATION INTENDENT at the Generating Station ver undertaking.

ates must have had a thorough tech- l practical training and sound experi- olving Senior Responsibility in the ration, Operation, and Maintenance of odern Electricity Generating Station. nce will be given to candidates who are or associate members of the Institution anical or the Institution of Electrical rs, or who possess equivalent professional ations.

alary will be £800 per annum, rising, to satisfactory service, by two annual ts of £50 to £900 per annum.

ppointment will be subject to the pro- of the Local Government Superannua- s, 1937, and the selected candidate will ired to pass a medical examination.

ications, which must be made on a pre- form, to be obtained from Mr. H. Pryce- M.Inst.C.E., Engineer and Manager, Brighton city Undertaking, Electric House, Castle , Brighton, 1, are to be delivered to him, e, "Power Station Superintendent," not n Noon on Tuesday, 31st August, 1943. ssing, either directly or indirectly, will ify.

J. G. DREW,
Town Clerk.

n Hall,
Brighton, 1.
July, 1943. 8092

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ance Examination for those not otherwise ed for admission, 21st and 22nd September. Scholarships, value £35 per annum, are on the results of this Examination. ION BEGINS, MONDAY, 11th OCTOBER. uctus sent free on application.

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SESSION COMMENCES on THURSDAY, EPTEMBER.

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sor A. H. GIBSON, D.Sc., LL.D., M. Inst. C.E., M.I. Mech. E. (Engineering).
sor WILLIS JACKSON, D.Sc., D.Phil., A.M.I.E.E., F. Inst. P. (Electrical Engineering).
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sor A. R. TODD, D.Sc., Dr. Philnat., D.Phil. (Organic Chemistry).
sor MICHAEL POLANYI, M.Sc., M.D., Ph.D. (Physical Chemistry).
sor P. M. S. BLACKETT, M.A., F.R.S. (Physics).
sor D. R. HARTREE, M.A., M.Sc., Ph.D., F.R.S. (Theoretical Physics).
sor F. C. THOMPSON, M.Sc., D.Met. (Metallurgy).
sor W. J. PUGH, O.B.E., D.Sc., B.A. (Geology). 8120


## The Engineer

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## PUBLIC NOTICES

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DOUGLAS H. INGALL,
Principal.

8116

## PUBLIC NOTICES

IN THE MATTER of LETTERS PATENT Numbered 313,017 and 313,032, each dated 30th December, 1927, and each granted to ROBERT FRENCH MACFARLANE, WILLIAM EDWARD PRESCOTT and BAKER PERKINS LIMITED for inventions each entitled "Improvements in and relating to Icing Biscuits and the Like."

**Notice is Hereby Given that** on the 19th October, 1943, an ORIGINATING SUMMONS (1943 M. No. 697) issued out of the High Court of Justice (Chancery Division) on behalf of the above-named Robert French Macfarlane, William Edward Prescott and Baker Perkins Limited, asking that the terms of the said LETTERS PATENT and each of them may be EXTENDED for the further period of four years and three months will come before the Honourable Mr. Justice Simonds for directions as to the hearing and that any person desirous of being heard in opposition must at least eleven days before that date lodge Notice of Opposition (giving an address for service within the United Kingdom) at Room 156 Royal Courts of Justice Strand London and serve a copy thereof upon the undermentioned Solicitors and upon the Solicitor to the Board of Trade.

Dated this 29th July, 1943.

COOTE and CO., 60, Lincoln's Inn Fields, London, W.C.2, upon whom all documents requiring service should be served. 8122

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**1941 No. 2069**
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ASSISTANT BUYER REQUIRED for Engineering works in West Country engaged on Aircraft Manufacture. Position holds definite future after the war for suitable candidate, who must have had experience in Buying, Office Routine, Purchase Progress, and Sub-Contractor Relations. In reply please state education, age, experience, and salary required.—Address, 8131, The Engineer Office. 8131 A

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Nottingham. 8124 A

PLANT MANAGER REQUIRED. Must have knowledge of Plant Management as related to Foundries and General Engineering Works. Write, stating education, experience, age, and salary required.—Address, 8132, The Engineer Office. 8132 A


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# The Engineer

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***Letters relating to the Advertisement and the Publishing Departments of the Paper are to be addressed to the Publisher; all other letters are to be addressed to the Editor of* THE ENGINEER.**

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# A Seven-Day Journal

## The Bombing of Ploesti Oil Refineries

On Sunday, August 1st, American "Liberator" heavy bombers based in the Middle East, belonging to the Ninth U.S. Air Force and numbering between 150 and 200 aircraft, successfully bombed the oil refineries at Ploesti, in Rumania. The machines made a round trip of 2400 miles, and it is estimated that some 2000 airmen, many with oilfield experience, who had received special training on a mock target erected in the desert, took part. This target was a scale model of the refinery lay-out, which includes no less than fifteen large and small refinery plants. The attack, which was made in face of strong defence, was the fourth which has been made by British, Russian, and United States bombers. The supply of oil from Rumania constitutes the major part of the Axis oil resources in Europe, and any damage done to the refinery plants will have an immediate and important effect on German's war effort. Reference may appropriately be made to an article which appeared in THE ENGINEER of April 18th, 1941, on the oil situation in Rumania, which was contributed by an engineer long resident in Rumania. It stated that about 5½ million tons of crude oil were probably being obtained from the Rumanian oilfields, and that the refineries at Ploesti and Campina had capacities almost double that of the present crude oil production. In addition, railway and water transport connections from Rumania to Austria and Germany have been improved and new pipe lines laid to facilitate the more easy transport of refined and crude oil products from the oilfields to the Danube. Further oil refineries are situated at Regensburg, in South Germany, which has also been bombed from time to time. Reports of the Ploesti raid, which was carried out at a low level, show that great damage has undoubtedly been done. Direct hits, it appears, were obtained on about seven of the largest refinery installations, including the Credit Minier refinery, which is reputed to be the only 100 per cent. octane petrol plant in Rumania. The installations, boiler houses, cracking plants, and fractioning columns, and also the power houses, were hit, and a considerable amount of the oil stock was burned. Many packs of incendiary bombs, high-explosive and delayed-action bombs contributed to the intensive damage caused.

## Jubilee of Manchester's Electricity Supply

SATURDAY, July 31st, 1943, marked the jubilee of the Manchester electricity undertaking, which from small beginnings has grown to one of the largest municipal supply undertakings in this country. It was on July 31st, 1893, that the engines in the then new electric lighting station in Dickinson Street were put on load. The No. 1 station was equipped with four 400 H.P. Galloway engines and six 100 H.P. Hornsby compound engines. The larger engines were arranged in pairs and were coupled to Elwell-Parker and Edison-Hopkinson dynamos by means of a jockey pulley belt drive. The output of the larger dynamos was 240 kW, and that of the smaller sets 60 kW. The supply was then available to about 112 consumers, which in 1894 had risen to 412 consumers. In the first eight months of operation less than 500,000 units were generated, and the revenue for the first year of operation was £10,000. In 1901 the second station at Bloom Street was brought into operation, and this plant consisted of four dynamos driven by slow-speed reciprocating engines, each of 2700 H.P. In 1902 the No. 1 station at Stuart Street, which was designed by the late Sir Alexander Kennedy, was opened with a capacity of 9000 kW, and it was followed in 1907 by the No. 2 station, designed by Mr. G. F. Metzger, which had two 6000 H.P. reciprocating engines, then among the largest in this country. In 1923 the No. 1 Barton station, designed by Sir Leonard Pearce, was opened, and its twin extension, which was planned by Mr. H. C. Lamb, was formally inaugurated in 1928. Some of these stations have been described and illustrated in THE ENGINEER, and the highly satisfactory results obtained by operating at high thermal efficiencies have been recorded. To-day the number of units generated by the Manchester undertaking is about 700 million a year, and the return some £2,500,000 per annum, while the latest turbine-driven generators each have a designed capacity of 50,000 kW and the number of consumers falls not far short of 200,000. On Saturday last a small exhibit, consisting of documents, maps, photographs, and old apparatus, illustrating the fifty years' growth of the undertaking, was opened at the show-rooms of the Manchester electricity department in the new Town Hall. It will remain open until to-morrow, Saturday, August 7th.

## American Locomotive Research

IN a Journal note of July 16th we announced the appointment of Mr. Lawford H. Fry to the position of Director of Research of the Locomotive Institute, New York City, a post which he took up on July 1st. For some years past the Locomotive Institute has been carrying out intensive studies in connection with the design of steam locomotives, and their performance, through a committee of technical representatives of the American locomotive-building firms. Many subjects have been dealt with and methods adopted, all with the object of improving performance, reducing maintenance costs, providing greater reliability and efficiency. These activities have yielded both positive and advantageous results. With, however, the necessary contribution of locomotive-building firms to the American war effort, it has been necessary to limit to a certain extent the time available to technical staffs for the continuation of these studies. The Institute is fully aware of the contribution which is being made daily by the United States railways in the handling of troops, materials, and supplies, no small part of which is due to the supply of locomotives available. Having this wartime task in mind, and looking forward to the problems of post-war transportation, it was decided that if the steam locomotive was to maintain its position as the main agent of railway transportation throughout the world, the research studies which were already begun should be continued without delay, a special organisation being set up to handle this work. Mr. Lawford H. Fry's entire time will be devoted to research work in connection with locomotive design under the jurisdiction of the Technical Committee of the Institute. The work already in hand will be accelerated, and a thorough investigation is to be made of the recent accomplishments which have already resulted in improving the performance of the steam locomotive to a point where yearly mileages are more than double what they were a few years ago. Mr. Fry's long experience is such as to make him specially qualified for the work he is now undertaking.

## Air Attack on Remscheid

ON Friday night heavy bombers of the Royal Air Force attacked a new target in the Rh neland. It was the town and district of Remscheid, not far from Düsseldorf and Wuppertal. Remscheid is famous for its machine tool industry, which includes makers of sawing machinery and saws, grinding and polishing machines, and precision tools of many kinds. Among the principal firms, examples of whose machines have from time to time been mentioned in THE ENGINEER in connection with articles on the machine tools which were shown at the annual Leipzig Technical Fair, may be mentioned the cold-sawing machines of Joh. Friedrich Ohler, of Remscheid-Vierhausen, which firm also manufactures saw-sharpening machines and inserted tooth saw blades. Other saw manufacturers in the district include the firms of C. W. Haas, Robert Rontgen and Gustav Lennartz. The Deutsche Spiralbohrer und Werkzeugfabrik, G.m.b.H., is noted for its high-speed drills and reamers and other tools. Its works are at Remscheid-Vierhausen. Another Remscheid-Berghausen firm is that of W. Ferd, Klingelberg, Söhne, which specialised in gear-testing and measuring machines and grinding and polishing machinery. Specialist firms in the making of precision machinery and tools include A. Ludwig Steinmetz and A. Strassmann. Josua Corts Sohn (suppliers of steel knives for shearing machines), and Krumm and Co. do a large trade in drop forgings of all kinds and special tools. At the factories of Otto Ortlinghaus Söhne laminated couplings are made which are fitted to all kinds of mechanical drives for transport vehicles. These couplings were used on the engines of the Zeppelin L.Z. 130, where they were employed for the compressor and supercharger drives, and they are, no doubt, now employed on many types of war machinery.

## Production Planning

IT is announced that the Ministry of Labour and National Service, in conjunction with the Board of Education and the Scottish Education Department, is organising part-time courses of lectures in production planning at various technical colleges throughout the country. The lectures will cover the following subjects :—Workshop Organisation and Lay-out of Plant, the Operation Lay-out, Materials, Quality Control, Motion and Time Study, Final Operation Lay-out, and Workshop Economy. The courses will normally be of twenty hours' duration, and will usually be given in evening meetings of two hours each. No fees will be charged for the courses, but no allowances or expenses will be paid by the Ministry for the course. They are intended for men and women engaged on planning work in firms or with experience of such work, and others with comparable experience who are capable of benefiting from the instruction given. The Ministry of Labour and National Service, the Ministry of Production, and the three Supply Departments hope that employers will support these courses by sending the names of suitable employees to the local employment exchange, and also that employees with appropriate qualifications will come forward on their own account.

## The Future of the Tinplate Industry

IN the course of his chairman's address at the fifty-fifth general meeting of the Briton Ferry Steel Company, Ltd., which took place at Briton Ferry on Thursday last week, July 29th, Colonel J. M. Bevan, the chairman and managing director of the company, made reference to the modernisation of the steel industry and the future of the tinplate trade. He expressed the hope that redundancy within the tinplate trade would be dealt with in the near future, as this question was, he considered, a preliminary to any reorganisation for the modernisation of the steel industry. It was, he thought, now generally recognised that the cold reduced tinplate was superior in quality to the old type of tinplate, and also cheaper in cost. If South Wales was to retain her position in the world's markets after the war, Colonel Bevan thought that it was essential that the industry should be modernised at the earliest opportunity. The small individual units of the pack mill type would have to give way to the modern continuous method of rolling. The smallest economic output of a mill of the continuous type was far greater than that of existing units, and the concentration of production into a much smaller number of individual installations would appear to be inevitable. He hoped that the existing members of the tinplate trade would recognise the position and agree to adopt a co-operative policy in order to ensure the successful future of the industry. If the lowest cost of production was to be achieved, it was probable that the initial hot rolling would have to be carried out in one large unit. The hot strip so produced would take the place of the existing sheet and tinplate bars, and would be distributed for completion in cold reduction finishing mills in South Wales.

# Engineers and the British Empire

By Professor MIDDLETON SMITH, M.Sc., M.I. Mech. E., LL.D.

No. V—(*Continued from page 84, July 30th*)

## Railway Construction in Canada

MY travels in Canada made me realise the comforts that are available for passengers and the remarkable work of construction that had been done during the building of the railways in the Dominion. The two long trans-Continental lines are great engineering triumphs. The Canadian Pacific Railway was the first line to span the Continent. It controls 21,275 miles of road bed. The Canadian National Railway traversed the whole width of the Dominion later. It operates 22,000 miles.

During the building of these two railways the engineers had a grim tussle with Nature. It was no simple task to provide supplies and provisions for the welfare of the scattered forces that were employed. Thousands of horses, scores of locomotives, steam shovels, and other equipment were used, as well as many thousands of men, before the gradient assumed its definite shape. There was the rock to be blasted, and the swamps, called "muskegs," offered stern resistance, and at times baffled the most experienced engineers. New ideas had to be evolved and submitted to the test. Often quiet, hard thinking became imperative, and every man was urged to suggest a practical solution to any problem that faced these pioneers.

The swamps often seemed to be bottomless. Time after time the ballast locomotive would drag train after train load of material and push it to the end of the dump. The rubble would squelch into the morass and disappear, concealing all evidence that a few hundred tons of spoil had been thrown into the "muskeg." The trains would continue to bring up the heavily laden trucks, the spoil in which would disappear from sight into the viscous mass. There was no hope of forming an embankment until these deep holes were filled. It often took weeks to make progress over a hundred feet. The cumbersome steam shovel in use 70 years ago would often remove the whole of a hill in order to fill up one of these swamps.

Another great obstacle to progress was the large number of rivers and creeks that had to be crossed. In many cases temporary timber trestling was provided to allow the trains to cross the stream; the bridgework was erected later. There were wide depressions to be crossed and the level of the gradient was as much as 30ft. above the surface of the valley, which very often was a shallow "muskeg."

Parties of men armed with axes felled the forest trees, and, as soon as the trunks were stripped of all branches, they were cleaned, bound together by a chain, and the poles were hauled to the depression so that the trestle could be built. It often took 10,000ft. of logs to make the structure. Then the embankment grew around the feet of the trestling, and soon the timber work disappeared beneath a solid earthen wall. The wood did not rot as much as was expected. It was usually finally replaced by more permanent material.

The work was continued during the winter, for there was no cessation during snow or frost. The men lived in the terrifying forest, where they heard the timber wolves howling, and often they were on very short food supplies. Sometimes there was a dreary 100 miles' toil through the hardest country imaginable, which the solitary engineer on survey work had to traverse. He collected his dog team and sleighs, loading them up with provisions and camp equipment. It was a story of adventure that surely could not be excelled in fiction. Sometimes a half-breed would accompany the engineer, but often the extra load for provisions, &c., made him prefer to cross the water-broken country and face the terrific blizzards alone. In the case of illness or accident, it meant a five or six days' struggle through the backwoods to reach help. The human qualities of courage, tenacity of purpose, and ingenuity were constantly needed for construction to be attained.

During the work there was mile after mile of ceaseless boring through rock of the hardest type. Often the blasts were of huge proportions. In one case a high cliff prevented advance, and it had to be destroyed. Shafts were sunk into the cliff and galleries were driven at several places at the bottom. Six months were spent in making pockets for the dynamite and black powder rammed into the base of the cliff. The cost of the explosive used was about £1000. When fired, the noise and shock was terrific. Some 30,000 tons of rock were scattered, and about a fifth of the 14,000 cubic yards were hurled into the lake. A large number of accidents occurred during work of this type, often because the men were careless. There is an axiom, "familiarity breeds contempt," and it was true when the sticks of dynamite were handled and warnings to keep well away from the flying rock were disregarded. In one section during seven months there was a casualty list of forty-two killed and ten wounded. During the building of the C.N.R. across Canada there were more deaths due to dynamite than any other cause and sickness combined—in spite of the tragedy of the seventy-four deaths on the Quebec Bridge.

On the C.N.R. main line 25,000 men were employed. Almost every mile of both trans-Continental lines commemorates some story of heroism. There was bitter struggle against frost-bite while working with the transit level rod, or chain, when the surveyors were in difficult country, where the temperature was often 40 deg. below zero. There are men who helped to build the railways now sleeping in the cemeteries up and down Canada, or lying beneath the soil of the woods, and others whose bodies were never recovered. Very few of the passengers who now travel in comfort realise the agonies endured by many of the engineers and labourers who built these lines across the Continent.

The administration and extension of these two great arteries of commerce have been subjects of heated political controversy in Canada, but we must omit considerations of these problems. It is important, however, to remember that there were also difficulties concerning the supply of finance needed, and that the money which made these lines possible was obtained, during periods of crisis, from the City of London.

Quebec Bridge

## Canadian National Railways

The first line in Canada to be constructed was to complete a rail-water route between Montreal and New York. That was in 1837; but railway construction in the Dominion lagged far behind that in the U.S.A. for some years. Indeed, it was the fear that the railway magnates in the U.S.A. would control lines in Canada that stimulated construction. The main influence that caused the first trans-Continental line to be built, the C.P.R., was the desire to bring the far-western province of British Columbia into the proposed Federation of Canada.

The latest line constructed is a branch of the C.N.R., a northern line which runs across the eastern provinces of Quebec and Ontario. This makes possible the further development of the rich mineral deposits in North-Western Quebec.

In the early days there was a sparse population, mostly concentrated in the eastern provinces, and not far away from the St. Lawrence River. The rocks and dense forests of the highlands in Ontario, and the great height of the Rocky and other mountains

further west, deterred any extensive railway construction until about 1870. Engineers had a very different life about a hundred years ago to that of to-day, when transport on waterways and roads are now so very much easier. The U.S.A. offered to them, to investors, and to settlers, better prospects; many of the isolated residents in the central provinces of Canada streamed south to seek the better prospects.

The Intercolonial Railway was built in the 1870s. It afterwards became a part of the C.N.R. system, which is now the largest, in point of mileage, in North America; it touches every principal city, ocean, and inland port of the Dominion; it serves every province. It was formed in 1923 by the amalgamation of the Canadian Northern and Grand Trunk Pacific Railway in the west and the Grand Trunk and Canadian Railway in the east. It is the property of the Canadian Government. It runs from the International Boundaries almost to the northern limits of Canada's mining, lumbering, and agricultural areas, as well as to the sea coast and inland fishing centres, manufacturing districts, &c. The main source of revenue is freight; but passenger traffic is attracted by streamlined, fast locomotives and air-conditioned carriages. Its extreme length is from Halifax in Nova Scotia to Prince Rupert in British Columbia.

The impulse to build this northern route through the north-west of the Pacific, when there was already the C.P.R., connecting Montreal and Vancouver, was caused by the armies of settlers that were pouring into, and farming, the country north of the C.P.R. line and west of Winnipeg in all directions. They could raise plentiful crops of grain, but unless their land was in the southern stretches of the country, where the C.P.R. offered facilities for freight, they could not sell their produce or obtain, easily, farm implements, &c.

### The Quebec Bridge

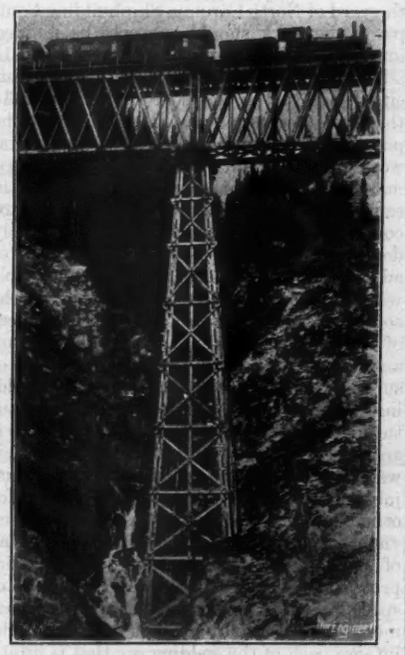
There always seems to be one supreme engineering accomplishment during the construction of any great railway. The C.P.R. had triumphed over the great obstacle of the Rockies; there was not so much public interest in the work of the C.N.R. engineers when they crossed the lower-level barrier over a more northern route. But the public imagination was stirred by the building by the C.N.R. of a colossal bridge across the St. Lawrence River, near the city of Quebec. It was, later, shocked by the tragedy which resulted from the first attempt to span the river.

The crossing of the navigable channel was a most difficult problem, for at the point selected it was over 1200ft. in width. The banks on either side of the river were high. The design and construction of this bridge was then the most stupendous undertaking made in this branch of engineering. At first it was suggested that the river should be tunnelled, but it was soon seen that the cost would make it impracticable. A ferry service, capable of handling a whole train, such as had been used on Lake Ontario, was not possible, because the river was closed with ice during several months of the year. And so it was decided to build a bridge. It was argued that if the Firth of Forth bridge, with a single span of 1710ft., were possible of erection and had stood the test of time, then surely a span only a few feet longer could be built. A cantilever bridge, 1800ft. long, with a clear space of 150ft. between the rails and high water, was designed. It was meant to carry heavy traffic.

One of the most experienced and largest bridge building firms in the United States secured the contract. American engineers had for a long time been anxious to eclipse the triumph of the construction and design of the great bridge in Scotland.

It was estimated that some 38,500 tons of steel would be required and that the total cost of the undertaking would be about £1,400,000. As soon as the scheme was approved, it was hurried forward with all possible speed and the work was commenced in 1902. At last the steel skeleton was within 400ft. of the centre of the river. The engineers followed the work very carefully, recording all deflections and movements of the structure as construction continued; calculations concerning the stresses and strain under changing conditions were constantly made.

It was in about the second week in August, 1907, that one of the engineers reported signs of weakness in one of the ribs of steel near the pier on the shore side. The resident engineer sent a colleague, post haste, to the U.S.A. consulting engineer—one of the greatest authorities on bridge building in the world—while another was sent to the head office of the bridge building firm. Unfortunately, construction continued and tragedy came on August 29th, 1907. It happened at the very time when the constructional engineers were drafting a message to the resident engineer to suspend operations.



TIMBER BRIDGE IN THE ROCKIES

The calamity was as sudden as terrible. Where a minute before you could see a handsome bridge arising, there was nothing but a crumbled, twisted mass of steel lying in the river and causing seventy-four men to lose their lives. All of the skill, enterprise, and accumulated knowledge, gathered together in the building of the bridge, was shattered in a few seconds, and 18,000 tons of steel were lying at the bottom of the river. It was a terrible shock to American bridge builders, for they had criticised the Forth Bridge as a structure containing far too much steel. But Sir John Fowler, Sir Benjamin Baker, and Messrs. Arrol and Sons had been determined to take no chances. The more conservative British engineers had thought the Quebec Bridge too light; they had never been attracted by American designs.

Although the accident was a terrible tragedy, engineers all over the world learned a lesson. The inquiry into the cause of the disaster revealed that there were deficiencies in knowledge both of steel and bridge designing. The whole story has been told in "Historic Accidents and Disasters," Nos. VII, VIII, and IX, in THE ENGINEER of October 24th and 31st, and November 7th, 1941.

The Canadian Government determined that the St. Lawrence should be spanned by a second bridge if they could be convinced it was humanly possible to do so. A Board of Engineers prepared designs and after three years of hard work they were accepted. The length of the cantilever span was reduced from 1800ft. to 1758ft. Thirty-eight different plans were laid before the Government Commission, and after due consideration the plans of a Canadian company, which differed considerably from the official design, were accepted and the work of erection commenced.

The new bridge was far less ambitious in design than the one that failed. The calculations were based upon the use of a lighter locomotive and train; the two roadways were abandoned, and the bridge became suitable only for railway transport with a pavement on either side for foot passengers. The estimate for the accepted design was £1,730,000. Whereas the official design required about 66,000 tons of steel—nearly double the weight for the first structure—the final design needed only 43,750 tons of metal.

### The Pioneer Surveyors

The one concrete effort to build 3453 miles of first-class railway track across Canada had been a colossal task, especially at a period when the total population of the Dominion did not exceed 6,000,000 people. It is true that both the Siberian and Cape to Cairo lines may seem to be more ambitious projects, but they were built in sections.

The engineers found the worst stretch of land around Lake Superior, where there is a great deal of rock muskegs and water. Gradients on the C.N.R. were not to exceed 21·12ft. per mile, and no curves were to be sharper than 4 deg., *i.e.*, of 143·2ft. radius.

The cost per mile was very much higher, and the construction difficulties much greater, between Port Arthur and Sudbury, than when building the route over the Rocky, Selkirk, and Cascade mountains. On the other hand, the survey and experience of the engineers who had built the C.P.R. line was invaluable. The C.N.R. surveyors often came across the stakes left by the C.P.R. surveyors who had explored the Yellowhead and other passes.

### Remarkable Bridge Building

It must not be supposed that this great single-span bridge over the St. Lawrence was the only gap that caused the engineers endless anxiety, and where the difficulties produced excitement and even thrilling adventures. Along the line between the Atlantic and Pacific oceans there were many other bridges of importance, too numerous to mention. There are over 240 steel bridges, and in one 200-mile stretch there are fourteen of these structures, one 700ft. long and five each 500ft. long.

The unstable nature of the river beds made it imperative to carry to great depths foundations. There were seasons when the rivers were in flood and solid, heavy concrete piers had to be built. The Frederick House River, for example, required a bridge 300ft. long and 75ft. above the high water of the river. The final structure was of steel; it replaced a temporary timber trestle, built when it was urgent to grade the opposite bank. The Mattagami River, a little further

west, is 600ft. wide where the bridge spans it. It is navigable for large vessels. The Cap Rouge Viaduct from end to end measures 3345ft.; it is 173ft. above the water and contains 4500 tons of steel.

It may surprise readers to learn that Red Indians were expert as assistants in bridge-building work. My own experience with Asiatic labour was that, if handled in the right way, natives can be trained to do good construction work, and that was the verdict of engineers on railway building in Canada.

The worst crossing was on the Pacific Coast. Prince Rupert, the terminus, is on Karen Island, and the Zanardi Rapids had to be spanned. In the constricted channel the water rushes under the bridge at a velocity of from 12 to 14 m.p.h. The bridge is nearly 1000ft. long; two spans are of 250ft., two of 150ft., and two of 55ft. each. It was the rise and fall of tides, varying 26ft., that made construction of the piers for the two central 250ft. spans so difficult.

For the Skeena bridge, 1200ft. long, a specially chartered ship brought 5000 barrels of cement from Hong Kong. That load, timber, and other gear, had to be hurried inland. Despite careful surveys, it was realised that the rocky bed, found by soundings, was rotten. There are two main centre spans, with piers 30ft. thick at the foundations and two shore spans. The velocity of the Skeena in flood and the crash of trees brought down from upstream presented difficulties not often met with in railway work. For many years the "Ambassador Bridge" spanning the river between Detroit and Canada contained the longest span, 1850ft., in the world.

### The Builders of the Railway

It is generally recognised that an experienced and dynamic American railway manager, C. M. Hayes, who first set foot in Canada in 1899, was the originator of this second Canadian trans-Continental route, running through much new territory. There was considerable opposition to the scheme, but Hayes was clever. He persuaded bankers to issue bonds in London, which were subscribed ten times over. The Canadian Government undertook to build half the line. Hayes took the British railways as a model, quoting "the straight level line wins."

A gradient of 21·12ft. per mile was decided upon. Engineers in North America said it was impossible to build over the confused heap of tangled, tumbled ice, snow-covered and precipitous Rockies with that gradient. An experienced surveyor, C. C. Van Arsdoll, who had spent most of his life on railway engineering work on American mountains, including the Rockies, was in charge of the survey in the west; he later built the line, as divisional engineer, in British Columbia. R. W. Jones was associated with him and explored in all about 10,000 square miles to find a route through the Rockies. Transportation was in its infancy, wagon roads had to be built at a cost of about £200 a mile; one of 170 miles cost £40,000. Forty possible passes were discovered and charted; finally, the engineer, B. B. Kelliher, an Irishman, selected the Yellowhead Pass, the summit being 3712ft. The first trans-Continental, the Union Pacific, had crossed at 8710ft.; the C.P.R. had reached a level of 5329ft. at St. Stephen, over the same great obstacle, well named "The Rockies."

It would be possible to collect an infinite variety of engineering details concerning the building of the C.N.R. and the C.P.R. across Canada; there is available extensive literature, much of it of great human interest. The Pacific termini for the two lines are some 550 miles apart.

The C.N.R. branch line to Churchill, on Hudson's Bay, has been of great benefit to Manitoba. The first train ran across Manitoba in 1929. It shortened the route from some prairie lands to Britain by 1000 miles. It opened up coal mines in Alberta and minerals in other provinces. Edmonton, the beautifully planned city of Alberta, is on the C.N.R. main line.

Before the global war nearly 40 per cent. of British capital investments (2725 million dollars) in Canada were in railway securities. It seems that as the population of the Dominion is certain to increase and mechanised industry develops the natural resources of the country in greater volume, the financial outlook for the C.N.R. should improve. In any case it has been of immense importance to Canada in opening up new areas and increasing trade.

*(To be continued)*

# America's Wartime Merchant Fleet

No. X—*(Continued from page 87, July 30th)*

### North Carolina *(continued)*

FOR the sake of a clear understanding of how "Liberty" ships are constructed at the yard of North Carolina Shipbuilding Company, the work should properly be divided into three broad sections—that done in advance at the fabricating part of the plant, either within the shops or on the ground; that done on the platens, skids, or inside the plate shop; and the concluding structural work on the slipways, where prefabricated materials and sub-assemblies are erected in each hull as the vessel advances toward completeness. Machine welding, as amply demonstrated at this yard, has a number of advantages over hand welding. It is possible with a welding machine to produce in the course of a ten-hour run quite 500 linear feet of butt or fillet welding, while the performance with manual welding lags far short of such a record. The desirability of the welding machine is emphasised whenever labour turnover becomes high, because then there is an inevitable slowing up of work while new welders are being qualified for their manual jobs. The welding machine is preferable for other reasons. When in use there is no visible flashing of the arc or the spattering of particles of molten metal that require protecting head gear, coloured goggles, or special dress to shield the workers; besides, men working nearby are not exposed to the intense flash of the welding arc that is injurious to bared eyes.

In the plant of North Carolina Shipbuilding Company, Unionmelt welding machines are widely employed, and they operate without any of the usual indications that an incandescent electric arc is in action. The copper-coated electrode of one of these units at the arcing point is covered, while at work, with a continuous deposit of granular welding flux, and that flux, when exposed to the heat of the arc—6000 deg. Fah.—melts instantly and cloaks the molten metal in the weld groove and shields it from exposure to the oxidising action of the ambient air. The welding machine, as it advances under its own power, simultaneously feeds the electrode and the flux at the required speed. There is no flashing, sparking, or smoke, and all essential operating functions of the machine, when set for a given performance by the operator, are thereafter regulated and automatically controlled electrically.

The essential transformers used with these welding machines are made handily portable by housing them in cages that can be lifted and shifted quickly to any part of the shipyard where machine welding has to be done. This procedure is far more economical and time-saving than would be the moving of sub-assemblies to stationary machines to have work done on them. Transportation by large cranes during sub-assembling is thus minimised as far as possible, and wasteful expenditure of power is obviated. This shipyard has in service numerous welding machines that are used whenever they may be needed—at the platens, at the side-shell skids, at any of the slipways, or elsewhere, as the tide of production changes. The welding machines do most of their work on flat surfaces, but they can be and are used satisfactorily on moderately sloping surfaces. On vertical surfaces and for short stretches in cramped places and for overhead welding, manual welding is relied upon. In each ship at this time 24,000 rivets are driven in the hull. The number of rivets has been reduced since the start of work at this plant, and machine welding has increased in the meanwhile, with a corresponding lessening of hand welding. These changes have contributed in a marked degree to shortening construction time.

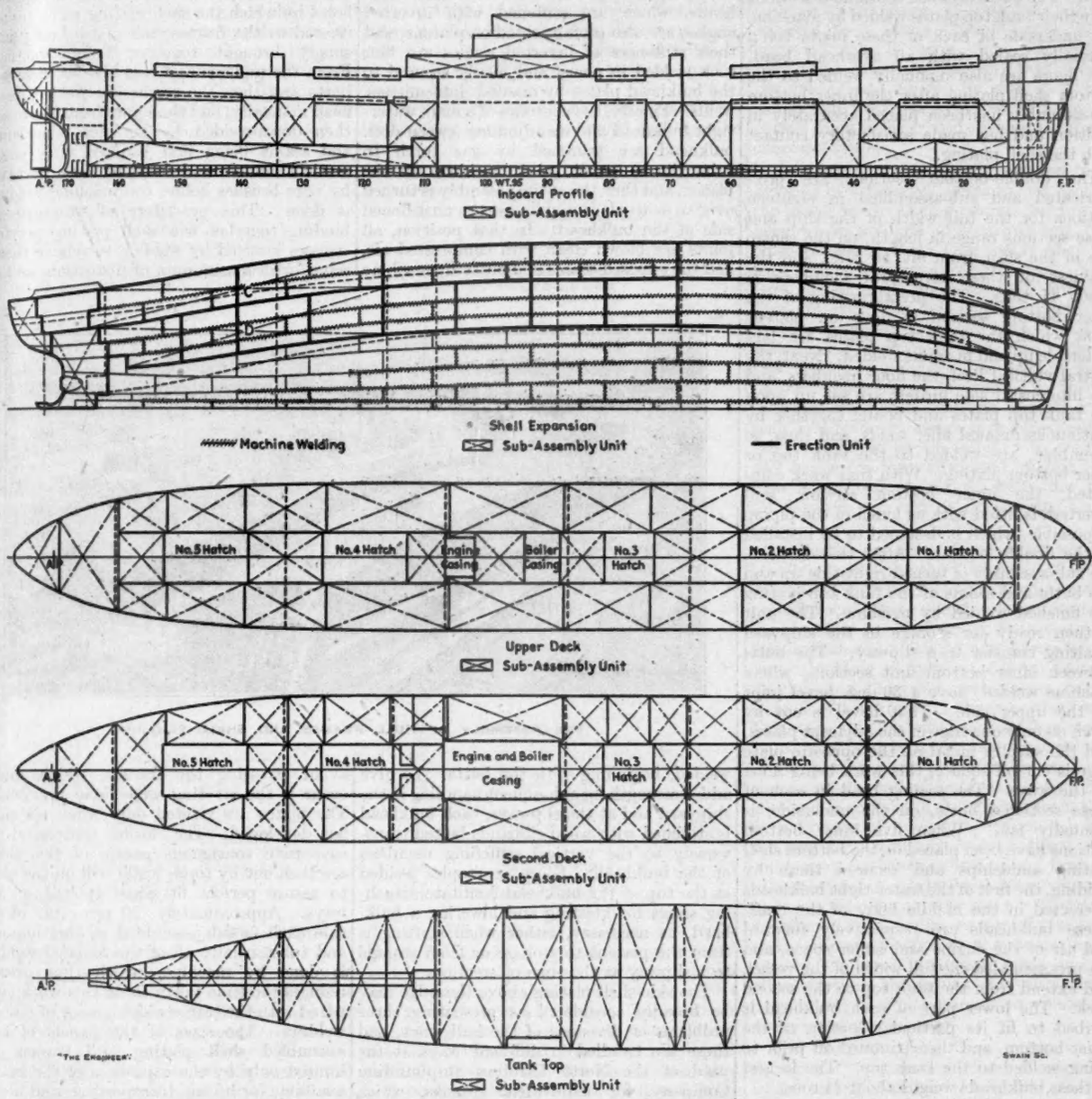
Accompanying drawings, used by David Arnott in a paper read by him before the Society of Naval Architects and Marine Engineers, illustrate the various sub-assemblies of the different structural units of a "Liberty" ship and help to a readier understanding of the extent to which sub-assembling is employed in the shipyard in advance of erection on the slipways. In this work machine welding is resorted to wherever feasible.

The slipways in the yard of North Carolina Shipbuilding Company are in no wise novel in their get-up, and the start of a "Liberty" ship, as is customary with most steel craft, begins with the laying of the flat keel plates on the keel blocks, from bow to stern, and, when accurately aligned, the butts of the flat keel are welded by machine. The keel plates are anchored in position by strong-backs fitted with turnbuckles to minimise any possible movement, and repeatedly at suitable intervals the alignment of the flat keel is checked up by transit. Incidentally, the surveyors are also watchful of any changes that may develop in the length and moulded dimensions of a hull while under construction in a slipway.

At the same time that the flat keel is in process of laying and the butts are being welded, transverse spauls or cradles are erected to support the succeeding strakes of bottom plating prior to their welding in a prescribed sequence. The edges of these bottom plates are prepared for welding, both at the butts and the seams, by being given an inclusive bevel of 45 deg. on the two adjacent upper or inside edges, while the under or outside groove of the same butt or seam also has a double bevel that has an inclusive angle of 60 deg. Until recently the practice at this shipyard was to deal separately with the different strakes of bottom plating—working

in each case simultaneously on the two sides of the centre line, the garboard strakes, port and starboard being laid in five lengths, and about equidistant forward and aft of amidships. These strakes, more familiarly known as port and starboard A strakes, were snugly lined up alongside the flat keel, to which they were joined by temporarily welded dogs. These dogs are simply pieces of scrap steel, about 8in. long, 1in. high, and ¾in. wide, that could be tack welded to the contiguous plates to hold them in position for the time being. The four butts of the five-plate lengths of each A strake section were then tied together by a manually laid overhead bead deposited from under the bottom plating. Next, the seams between the two A strakes, port and starboard, and the flat keel were similarly welded on their undersides initially by beads laid in overhead positions by the welders. The dogs along these two seams could be quickly detached with the aid of propane-oxygen torches in preparation for machine welding from the upper wide of the four butts of the A strake plates and the seams between the two A strakes and the flat keel. But before the down welding of the butts and the seams were done by machine, the butts and the seams were caulked with a pneumatic hammer fitted with a sharp tool, after which wire brushes, used by hand, removed all foreign matter in each groove before beginning the machine welding. The procedure adopted obviated the need of chipping the root bead before doing the machine welding. Owing to the greater penetration of the arc of the automatic welding machine, it is not necessary between two adjacent surfaces to have an opening between the plates to be welded. However, some gap does usually exist, which is filled by the molten metal laid in a weld. The seams have been and still are simultaneously welded on both sides of the centre line of the ship, the machine advancing from the after ends of a straight section and continuing to the forward ends.

Now, the keel plates and the contact edges of the A strakes are welded as just described, but, instead of dealing in the same manner with them, the succeeding B strake sections and C strake sections, on each side of the centre line are not put together on the ship, as heretofore, but the A strake, B strake, and C strake sections on each side of the centre line are assembled on platens, and as a unit are moved to a slipway and lowered into their assigned position and secured to the keel plates, in the way already mentioned, at the junction of the A strakes and the keel plates. On the assembly platens the butts and the seams are advanced alternately forward and aft, in their assumed positions in relation to the centre line of the ship, and by this procedure any stresses induced by welding have a chance to relieve themselves, and whatever distortion may develop is of an order that will not interfere with the subsequent easy fitting of the double-bottom assemblies that follow and rest upon the bottom-shell plating of the vessel. Thus, there is a physical gain, the welding of a number of A, B, and C strake plates into a single unit under favourable conditions on the platens makes for still better workmanship and the subsequent placing of these units on a slipway is done with greater ease and a saving in time. When fitting double-bottom assemblies, the bottom shell plating can be drawn into prescribed conformation with the aid of strong backs and turnbuckles




STRUCTURAL UNITS OF A "LIBERTY" SHIP

attached to pad-eyes, temporarily welded to the inner surfaces of that plating, or, conversely, similar instrumentalities, pulling outward, can be used to spread the bottom plating to allow an inner bottom assembly to settle snugly into place while being welded to the vessel's shell. The gradual extension of the bottom plating toward the bow and toward the stern minimises residual stresses and distortion prior to making junction with contiguous sections.

The placing of the double-bottom sections on the bottom shell plating is begun amidships. The butts between contiguous sections have their tank top plates welded by machine, the underside of each of these joints being manually sealed with an overhead bead. The floors are also manually welded to the bottom shell plating after the inner bottom sub-assembly has been placed accurately in position and has made satisfactory contact with the shell plating.

The double-bottom sections are prefabricated and sub-assembled in eighteen sections for the full width of the ship and these sections range in length, on the centre line of the ship, from 9ft. to 27ft., and the heaviest of these structural members is about 41 tons. The prefabricating of the inner bottom section is done on platens upon which the tank top plates are laid underside up and machine welded. Next, the central vertical keel, the floor members, and the intercostal side girders are set up upon the tank top plates and bound together by continuous manual fillet welds, and then, so assembled, are welded to the tank top or inner bottom plating. With that work completed, the inner bottom section, still inverted, is fitted with as much of the piping as possible, which is designed to be installed in the double bottom. After that is done, the sub-assembly is turned right side up and the butts and seams of the tank top plating are finished welded by machine. The unit is then ready for storage in the shipyard awaiting transfer to a slipway. The butts between inner bottom unit sections, where machine welded, have a 30-deg. bevel joint on the upper side. That bevel is cut by torch on only one edge of the adjacent plates, and the surplus metal on the opposite plate edge is cut off square, this work being done on the ways. The sealing bead in each of these sectional butts, on the underside, is manually laid. When five inner bottom sections have been placed on the bottom shell plating amidships and secured there by welding, the first of the water-tight bulkheads is erected in the middle body of the craft. These bulkheads are respectively forward and aft of the engine and boiler space, and are preassembled the full width of the vessel, and extend from the tank top to the second deck. The lower part of each bulkhead is scribed to fit its particular section of the inner bottom, and then trimmed off prior to being welded to the tank top. The largest of these bulkheads weighs about 24 tons.

In prefabricating these main bulkheads, their plates are laid out, edge to edge, on a platen, with the stiffener side up, but with steel strips, about 2in. wide and $\frac{1}{8}$in. thick, laid under each joint to be welded, to serve as stops, and the plates are dogged down at the edges in the way already described for the bottom shell plating. So tied together in their proper positions, then the butts and seams are tack welded, the welds being 1in. long, spaced about 1 ft. apart for plates that are more than $\frac{3}{8}$in. thick, and with $\frac{1}{4}$in. tack welds, spaced about 8in. apart, for thinner plates. The butts are welded first, and next the seams, the work being done by welding machines. The plate edges are not bevelled, and the squared edges of adjacent plates are separated by gaps of from $\frac{1}{16}$in. to $\frac{1}{8}$in., determined by the thickness of the plating. The I section stiffeners on the main bulkheads are then laid on the welded plates in their prescribed positions, and tack welded, and this is followed by double continuous fillet welds, this work being done by welding machines travelling at the rate of 2ft. a minute. Instead of moving on a track, the welding machines are so equipped that one wheel can be turned to act as a guide when using the upright member of the stiffener for that purpose. The lighter 'tween-deck bulkheads, which are stiffened with inverted angles, are also prefabricated on platens, and their stiffeners of inverted angles are first tack welded in place, and finally secured to the bulkhead plates by manual intermittent welds. Finally, the contours of a main water-tight bulkhead and its adjoining 'tween-deck bulkhead are trimmed by gas torch to subscribe to punch-point markings on the platen, and then the entire assembly is turned over so as to place uppermost the unstiffened side of the bulkhead. In that position, all joints are blown clean with compressed air, and the exposed seams and butts are machine welded, beginning with the butts. To give added strength for subsequent handling in the shipyard and at the slipways, each bulkhead is stiffened with wood ribbands bolted transversely to the vertical stiffening members of the bulkhead. Loops or staples welded at the top of the bulkhead facilitate attaching slings for hoisting and lowering a bulkhead, as necessary, either when shifting it from the platens to storage or from storage to a slipway at the time of erection.

The side-shell plating above the bilge may be broadly considered as presenting three problems or divisions of the hull work, and these are handled in different ways at the yard of the North Carolina Shipbuilding Company, for self-evident reasons, which will be presently understood. Between the collision bulkhead and the after-peak bulkhead, the side shell is put together in panels that cover the three strakes above the bilge. There are thirteen sections of this assembled skin that have lengths of from 20ft. to 30ft. Above these three strakes, similar panels form the sheer strake and the top-side strake, and there are eight of these panel sections of different lengths. The average weight of the various side-shell panels is around 14 tons. Forward and aft of the side-shell plating mentioned, the bow and stern structures and their skin plating are dealt with separately, and have to be handled differently in assembling them for erection.

The sections or panels of the flat areas of the shell plating throughout the midlength of each side of a "Liberty" ship are laid out on low skids and prepared and handled in much the same manner as the bottom shell plating, except that the frames to which the plates will be riveted are first arranged and secured to the skids before the shell plating is laid on them. The edges of the plates are bevelled in advance to a 45 deg. included angle on the upper or outside, and bevelled to a 60 deg. included angle on the inside or underside, as placed on the skids. The plates are service bolted to the frames through the holes by which the shell plating will later be riveted to the frames, the plates being first snugly brought together before bolting. From the underside of this lay-out, first the butts and then the seams are welded overhead manually, and the joints from above are then down-welded by machine, the butts and seams being first caulked with pneumatic hammers and freed of loose particles by wire brushes before the machine welding is done. This procedure of progressively binding together the shell plating permits stresses induced by welding to relieve themselves with a minimum of distortion, and so avoid stressing the frames, which might occur if the riveting were done previously. The plates are riveted only when all creep has developed. The closing sections of the successive contiguous panels of the plates are then cut by torch while still on the skids to assure perfect fit when erected on the ways. Approximately, 90 per cent. of the side shell is sub-assembled in this manner, and substantially all of the finished welding is done by machine, which thus greatly reduces the time taken to do this work compared with the earlier employment of manual welding. The sizes of the panels of sub-assembled shell plating and frames are limited only by the capacities of the cranes available for lifting, transporting, and lowering the sections in shifting them from storage to the slipways.

The shaped lower side-shell assemblies, forward and aft of the flat perpendicular 'midship side-shell sections, are also sub-assembled, but the work is done on specially prepared skids or cradles, which are so modelled that they hold the steel frames in slotted recesses and subscribe to the moulded form of the hull. These curved surfaces do not admit of the use of welding machines, and therefore all welding required is done by hand. The butts and then the seams are manually welded on the outboard side of the assembly, and when that welding is completed the plates are riveted to the frames,

PRE-ASSEMBLY OF HULL FRAMES AND SHELL PLATING

and the sub-assembly is then ready for erection in a hull. When the assembly is erected the inboard side or root bead of the primary welding is chipped to good metal, and the joints completed by manual welding.

The bow assembly of a "Liberty" ship includes the collision bulkhead, the forward part of the upper and second decks, the stores flat, the chain locker, and the centre line swash bulkhead. This structure is assembled clear of the ways, temporarily bolted together, and the butts and the seams of the shell are manually welded before the plating is riveted to the frames. A bow assembly is really in two parts, which are separated at the second deck into an upper and a lower sub-assembly. This is done to make erection on the ways easier, inasmuch as an upper or a lower section weighs about 47 tons. The main stern assembly, which includes the stern frame, is also fabricated in a kindred manner and on the ground, and the stern abaft the transom is assembled on the ground.

*Thirty-six-day Erection Schedule*

| Days. | | |
|---|---|---|
| 1 | ... | Flat Keel |
| 2 | ... | Bottom Shell |
| 3 | ... | Stage Stern |
| 4 | ... | I.B. (4 sects) 78–116 |
| 4 | ... | Stern Assem. |
| 4 | ... | Boiler Foundations |
| 5 | ... | F.O. Settling Tanks |
| 5 | ... | Thrust Block |
| 5 | ... | Thrust Recess |
| 5 | ... | Bilge Keel |
| 5 | ... | Bhd 88 |
| 5–6 | ... | I.B. (8 sects) (116–140) (78–37) |
| 6 | ... | Bhd 108 |
| 6 | ... | Mach. Flats |
| 6 | ... | Lower Shell 91–116 P/S |
| 6 | ... | CL Bhd 82–88 |
| 6 | ... | Bhd 68 |
| 7 | ... | I.B. (3 sects) (37–16) (140–148) |
| 7 | ... | Bhd 39 |
| 7 | ... | Steady Bearing Fdns. (Fwd 134) |
| 7 | ... | S.A. Fwd |
| 7 | ... | CL Bhd 60–68 |
| 7 | ... | CL Bhd 68–74 |
| 7 | ... | CL Bhd 39–46 |
| 7 | ... | Stage No. 3 Hold |
| 7 | ... | Stage No. 2 Hold |
| 8 | ... | I.B. (3 sects) (12–16) (148–162) |
| 8 | ... | CL Bhd 25–39 |
| 8 | ... | No. 3 2-Dk Hatch and Girds |
| 8 | ... | No. 2 2-Dk Hatch and Girds |
| 8 | ... | Lower Shell 48–91 P/S |
| 8 | ... | CL Bhd 108–116 |
| 8 | ... | Bhd 116 |
| 8 | ... | Bhd 25 |
| 8–10 | ... | Lower Shell 116–161½ P/S |
| 8 | ... | Deep Tank Flats 25–39 |
| 8 | ... | Pillar Fdns on SA Fwd |
| 9 | ... | Bhd 134 |
| 9 | ... | CL Bhd 12–25 |
| 9 | ... | CL Bhd 128–134 |
| 9 | ... | Steady Bearing Fdns Aft 134 |
| 9 | ... | Shaft Alley Aft |
| 9 | ... | Stage No. 4 Hold |
| 9 | ... | Boilers |
| 9 | ... | 2-Dk Girds 88–108 |
| 9 | ... | Deep Tank Flat 12–25 |
| 9 | ... | Horiz. Girds in Midship Tanks |
| 9 | ... | No. 4 2-Dk H-End-B 7 Girds |
| 10 | ... | Pillar Fdns on Aft S. Alley |
| 10 | ... | Pillar Fr. 98 P/S |
| 10 | ... | Bhd 156 |
| 10 | ... | CL Bhd 32–39 |
| 10 | ... | CL Bhd 134–140 |
| 10 | ... | Tunnel Recess Flat |
| 10 | ... | CL Bhd 12–17 |
| 11 | ... | Start 2-Dk |
| 11 | ... | CL Bhd 154–161 and Trunks |
| 12 | ... | Stage No. 5 Hold |
| 12 | ... | Lower Bow |
| 12 | ... | No. 5 Hatch 2-Dk and Girds |
| 12 | ... | Stage Bow |
| 12 | ... | Lower Shell 12–48 P/S |
| 13 | ... | Stage No. 1 Hold |
| 13 | ... | No. 1 2-Dk Hatch |
| 13 | ... | Complete 2-Dk Girds |
| 14 | ... | Complete 2-Dk |
| 15 | ... | Upper Bow |
| 15 | ... | Misc Bhds 1008 |
| 16 | ... | Upper Shell 48–116 P/S |
| 16 | ... | F.W. Tanks |
| 16 | ... | Misc Bhds 908 |
| 16 | ... | Transom |
| 16 | ... | 'Tween Dk Bhd 88 |
| 16 | ... | Stage Upper Bow |
| 17 | ... | 'Tween Dk Bhd 68 |
| 17 | ... | Engine Rm Casing |
| 17 | ... | No. 3 U-Dk Hatch and Girds |
| 17 | ... | Upper Shell 116–162 P/S |
| 18 | ... | 'Tween Dk Bhd 108 |
| 18 | ... | 'Tween Dk Bhd 162 |
| 18 | ... | U-Dk Girds 88–108 |
| 18 | ... | 'Tween Dk Bdh 134 |
| 18 | ... | 'Tween Dk Bhd 39 |
| 19 | ... | Upper Shell 13–48 P/S |
| 19 | ... | Stage No. 1 Hold |
| 19 | ... | All Vents and Escape Trunks |
| 20 | ... | No. 4 U-Dk Hatch and Girds |
| 20 | ... | No. 5 U-Dk Hatch and Girds |
| 20 | ... | 'Tween Dk CL Bhds |
| 21 | ... | Start U-Dk |
| 21 | ... | No. 2 U-Dk Hatch and Girds |
| 21 | ... | No. 1 U-Dk Hatch and Girds |
| 21 | ... | Complete U-Dk Girds |
| 23 | ... | Complete U-Dk |
| 25 | ... | Lower House |
| 26 | ... | Mast Houses |
| 27 | ... | Upper House |
| 28 | ... | Fwd Gun Fdn. |
| 29 | ... | Masts |
| 29 | ... | Dk House Wings |
| 29 | ... | After Dk House |
| 32 | ... | Hatch Beams |

The tabulated erection schedule gives in detail the sequence of the work for anyone particularly interested in the matter, but from now on the building operations will be dealt with in only a general way. It will be recalled that we mentioned the erection of the engine-room bulkheads which followed the completion of a sufficient expanse of the bottom shell plating. Logically, other internal assemblies are installed in the lower parts of the building ship. These include fuel oil settling tanks, centre line bulkheads, flats, hatch-end frames, deep tanks, shaft alley, &c., in their due order and welded into place after being properly fitted. When certain phases of this work have gone forward far enough, the lower side-shell panels are erected, working centrally forward, after which the sub-assembled second-deck hatches with their end beams attached to the forward and after framing are put in place and joined to the centre line bulkheads. The central panels of the second deck plating, previously assembled on the ground, with beams attached, are set on the bulkheads and girders and secured in place as they are fitted, this work starting amidships and progressing forward and aft, simultaneously on each side of the centre line. Such lower side-shell panels as have not already been erected are then erected prior to installing the outboard second-deck panels. The lower bow assembly is also now erected. Such shell plates as are not included in sub-assembled panels are fitted and welded in much the same sequence as that followed in dealing with the bottom plating. All main transverse bulkheads are welded to the shell after the hold frames are welded to the inner bottom, the second deck, the flats, &c. The sub-assembled butts in the shell, both forward and well aft, are the last to be welded.

Only when most of the welding has been finished upward to the second deck are the 'tween-deck bulkheads erected, and with these bulkheads in place the upper-shell panels are installed, starting from amidships and advancing on both sides of the centre line towards bow and stern. The transom and upper bow assemblies are erected about this time. Work next proceeds on the upper deck by placing the box-hatch assemblies and girders, and the upper-deck panels of plating are laid in the order described for the panels of the second deck. The upper-deck units, now set up, are then joined to the upper parts of the 'tween-deck contiguous units, and next the 'tween-deck frames are welded to the decks. With that done, the final work on the shell plating is that of welding the last of the assembly butts of the hull skin, and, following that, the butts and seams of the shell plates, at the ends, are welded. The concluding work on the body of the ship consists in welding the 'tween-deck bulkheads to the entire surrounding structure, and in this manual welding is exclusively employed for the purpose.

The various deck houses, such as the living accommodations, the mast houses, and the house aft for the steering gear, are either wholly assembled or sub-assembled to an advanced stage of completion on platens in the shipyard, and as separate units are eventually transferred to the slipways and erected in their designed positions on shipboard by the large cranes. The superstructure amidships, where the quarters for the personnel are located, is made up of three assemblies that are handled as such during erection. The lower house on the upper deck is formed of two athwartship sections, each weighing 38 tons, and the two levels of superstructure above the boat deck are constructed as a single assembly that weighs approximately 60 tons. The smokestack, ventilators, masts, &c., are sub-assembled on the ground and erected on shipboard when the topside work has advanced far enough to permit them to be erected without hampering other operations.

In many of the shipyards engaged in the building of "Liberty" ships the tendency of the newer welders doing manual welding has been to be prodigal of their welding rods, often scrapping them long before they had been used to their practicable utmost. North Carolina Shipbuilding Company, well-nigh from the beginning, has paid close attention to the conservation of electrodes, and by maintaining supervision of expenditures has thus greatly reduced the likelihood of wastefulness. Each welder is required to burn off in actual work each electrode down to a 2in. stub, and before he can receive a fresh supply the returned stubs are weighed to discover any loss in the form of unused welding rods. This is a worth-while precaution that pays dividends in economy of considerable magnitude.

While the majority of the shipyards now building vessels for the "Victory" fleet use oxy-acetylene burners or torches for cutting prefabricated plates and shapes and for heating the steel to offset residual stresses or to reduce distortion due to the effects of the heat of welding, at the yard of North Calorina Shipbuilding Company propane gas is used instead of acetylene for flame-cutting work. This very volatile hydro-carbon, from petroleum, is utilised because previous experience at the parent plant proved that its overall characteristics had advantages. The propane is stored in tanks and distributed from them by a system of welded pipe lines, covering the shipyard, with terminals at every point where the gas is likely to be needed. Propane, as a substitute for acetylene, has given complete satisfaction at this plant. Oxygen is distributed by a similar system of pipe lines, and compressed air for the operating of various kinds of pneumatic tools and for other services throughout the shipyard is transmitted in a like manner to all sections wherever of possible use.

The shipyard has been planned and equipped to assure flexibility of operation while functioning on a schedule that is designed progressively to step-up production. In the fabricating shops and in the sub-assembling work the aim is to turn out materials and parts for six ships at a time, and so make concentrated use of mechanical facilities and man power with a minimum of change in the use of tools and the work of the men using them. This notably lessens the likelihood of any lost motion. As originally planned, the plant was to be a six-way shipyard, and the preliminary schedule called for building one "Liberty" ship every eighteen days with the six ways, the building progress differing, of course, on the several ways. Subsequently, when the yard was provided with nine ways, the construction

schedule was accelerated, and at this time the output averages better than one ship per way per month. At the time of launching each "Liberty" ship, the vessel is so far advanced that the interval between launching and delivery to the U.S. Maritime Commission is at present seven days. The time at the outfitting pier prior to acceptance speed trial may be as brief as six days. On April 22nd the North Carolina Shipbuilding Company launched its eighty-eighth "Liberty" ship, and the programme called for the launching of ten ships by the close of that month. The shipyard force then totalled 20,300, and included a considerable number of women engaged in construction operations. Recalling how the vast majority of these people had to be trained for their jobs, the record made by the company becomes all the more commendable.

*(To be continued)*

# Scientific Research

ON July 15th and 20th the House of Lords debated Scientific Research. On the second day Lord Cherwell made an important speech. We reprint below, from "Hansard," some excerpts from it.

Professional scientists, who make rather a fetish of meaning the same thing when they make the same noise, are rather taken aback at times by the way the word "scientific" is used. So far as I can see its meaning has been extended to-day and last Thursday to comprise any or all of the adjectives "exact," "logical," "sensible" or even merely "reasonable." Of course this is very flattering to the scientist, but it seems to stretch the word rather beyond its original meaning. I hope I may be forgiven if I use the word myself in a rather narrow, perhaps more scientific, sense.

* * * *

Whether we like it or not, we have frankly embarked on the rake's progress of using up our inherited capital of coal and oil. Industry, which could not exist without power, is banking —I trust this is the right word rather than gambling—on the scientists to find a substitute. Unless and until we can do this, whether by turning sunshine economically into electricity —which, of course, would make the Sahara one of the richest regions in the world—or perhaps by evolving some way of utilising the nuclea energy of the atom, ultimate exhaustion of our fuel resources and a return to the mediæval conditions—when the heat we could get was measured by the wood we could grow—stares us in the face. As I have said, we are banking on the scientist to find alternative sources of power before our coal runs out. It is clearly important to know how long this will be.

The recent transfer of our coal resources to public ownership is of the first importance. It is the business of the Coal Commission to take careful stock of their property and the process of valuation has had the incidental result of disclosing much useful information to supplement the work of the Department of Scientific and Industrial Research and of the Geological Survey. Not only is the amount of coal being surveyed, but the type of coal is also being assessed. We shall soon therefore know much more than we have ever known in the past about our coal resources, both in quantity and quality. As a result, we shall find out how long it will be before scientists have to find a new source of energy. I think that this meets one of the very valuable points made in the report of the Parliamentary and Scientific Committee. If we must live on capital, there is clearly every reason and argument for trying, at any rate, to make that capital last as long as possible. For this reason, the insistence of the noble Viscount that we should spare no pains to discover ways of using our coal economically must be welcomed by us all.

Coal is valuable for two distinct reasons. In the first place, as I have said, on account of its calorific content; in the second, because of its latent chemical energy. It is the only material, apart from oil, found in quantity on this planet whose affinity for oxygen has not been satiated in the course of geological time. When we burn coal carefully we get back a good part of the solar heat used up when the plants were growing in their paldeozoic swamps. This is all right (provided we are reasonably economical) as long as we only want to boil our water or cook our food or warm our rooms. It is when we come to the conversion of the heat stored in the coal into other forms of power, usually by driving steam engines, that it is impossible to prevent a great deal going to waste. Naturally, industry has every incentive to economise; more and more elaborate devices are invented to save even 1 per cent. here and there. But the broad fact remains that something less than one-fifth of the stored energy of the coal is converted into useful forms of power.

I am speaking of total energy, and, as your lordships know, there is an absolute limit set by the law of dynamics to the possible conversion factor depending on the temperature at which oxidisation occurs. For generations it has been the dream of the physical chemist to oxidise coal at low temperatures when a vastly greater fraction could be obtained. I am not sure that the problem should not be tackled anew in the light of modern knowledge. English industry, of course, has grown up on cheap coal, and it is no use denying that it has taken longer than in some other countries for us to modify our machinery in order to save it. Nor is this altogether surprising when we think of the capital cost involved. It is so often easy to point our economies which, though superficially real, are fundamentally false. It is not always mere conservatism which prevents change. There is a form of survival of the fittest even in machinery. I think that many obvious improvements in efficiency could be pointed out whose capital cost would outweigh the gain that could be made by adopting them.

I am not sure whether your lordships realise quite how much research on fuel is going on. We have the Government's Fuel Research Station at Greenwich, the British Coal Utilisation Research Association, and the Gas Research Board. In addition, the Electrical and Allied Industries Research Association is working on the efficient use of fuel for the generation of electricity, and the Iron and Steel Industrial Research Council is studying the metallurgical use of coke and other fuels. The first three bodies I have mentioned alone are spending £360,000 a year, and more than half of this is found by the Government. There is, therefore, every reason to suppose that after the war, when more suitably qualified men become available, there will be a considerable expansion of this work. At least I can say this on behalf of the Government, that if industry puts forward proposals for any sound scheme of expansion of industrial research it will find a sympathetic and generous response from the Government.

As I have said, coal is valuable not only as a fuel to give us heat and power; it is also far and away our most important chemical reducing agent. Without it, it is difficult to see how iron and steel could be got in industrial quantities. Further, it is one of our most important sources of organic compounds. We must beware of wasting the heat stored in our coal; but it is far worse to destroy these valuable molecules which have been built up in the course of scores of millions of years. No one can doubt that the most painstaking investigation is worth while in order to find out the best way of using these compounds which Nature has provided for us so plenteously. Research into these matters is going forward all the time in the laboratories of the great dyestuff corporations which have such an immediate interest in these substances. I welcome, too, the recent announcement that the coal industry is to set aside £400,000 for research into the production of these valuable chemical compounds from coal.

* * * *

Government research is carried on at research laboratories under the Advisory Council of the Department of Scientific and Industrial Research. It is not easy to draw an exact hard-and-fast line defining the subjects they study. The best line of demarcation, if we must have one, would probably be to say that this research deals primarily with matters on which Government Departments may require scientific advice and assistance; that is to say, topics concerning the whole community, such as building, food, or fuel. Assistance to pure, fundamental research has been given in the past in the form of grants to universities and colleges in various forms. There have been direct grants to assist or even to initiate definite scientific research programmes; there have been grants to students in training to enable young men who have shown ability in the universities to spend two or three years on research; there have been a limited number of senior research awards to men of proved capacity, and there have been grants to leaders of scientific thought to enable them to maintain research assistants. In the last decade I must admit that the emphasis has tended rather away from fundamental research to the industrial side, but the whole distribution of effort is now being reviewed, and I personally hope that it may be agreed to extend considerably Government support to purely scientific research.

* * * *

In considering these questions it is essential to distinguish between the different types of activity which are so often lumped together loosely under the term "research." We have first of all the simple, straightforward, clear-cut need to improve and cheapen processes of manufacture—sometimes called development or works research. Clearly this is necessary, and indeed essential, if we are to hold our own. But it seems unlikely that the Government can, or should, do it. Only those actually engaged in the operation are likely to know what directions are likely to be worth pursuing. On a somewhat higher level, I should reckon research directed towards the production of new industrial products. Here, again, the Government do not usually intervene directly. With regard to products which would be of use to the whole community, such, for instance, as alloy steels or drugs, the policy has been to try to fill up gaps rather than to compete with industry. Finally, we have what I should call scientific research proper; that is to say, fundamental scientific research. It is extremely difficult, as I know to my cost, to make people realise the importance of this and its value to the community; yet without it science cannot exist.

Perhaps I may give two examples apposite to the main topic. Natural science is not, as some people think, a fixed collection of rules which can be learned and applied. It is a constantly growing and developing system in which we are continually discovering—or trying to discover—new generalisations or laws and new links and connections between previously unrelated domains. The physical chemists, who spent many millions of pounds on the hydrogenation process of coal, could never have dared to take such a risk if they had not been guided and fortified by what is known as the Third Law of Thermodynamics, enunciated some thirty years ago. This law is linked up with, and forms part of, the quantum theory, with its metaphysical roots. It was established and confirmed by observations of the most diverse phenomena—to name only a few, by measurements of the heat capacity of substances at temperatures very near the absolute zero; by relating these results to the distribution of colours in the spectrum of a hot body at various temperatures; and by relating both of them to the voltage required to prevent

electricity from being emitted by metals when illuminated by light of various wave lengths.

As has been said, it is no use imagining that we can solve practical problems if we do not know the laws of nature which govern them. But who would have imagined that these apparently unrelated investigations would facilitate the production of oil from coal? Nobody who was told to find out how to make petrol from coal and water would have started in this roundabout way. But because of the enunciation of the Third Law of Thermodynamics by Professor Nernst, and because the scientific foundations were there, it was possible and safe to launch out into the vastly complicated, difficult, and expensive industrial development which has enabled us to make artificial liquid fuels.

Let me give one other instance. As your lordships know, it was discovered some forty odd years ago that atoms of electricity—electrons—are emitted from hot bodies. These electrons are accelerated in an electric field in much the same way as a stone which falls to the ground—or perhaps an apple is a more usual illustration—is accelerated by the earth's gravitational field. They are deflected in a rather more complicated way by magnetic fields. The study of all these matters—exactly how they were affected by the various fields, and how these depended on their state of motion—did not appear to have any industrial interest forty years ago. It seemed to be the purest of pure science. Yet upon the knowledge thus secured rests the whole of the radio industry, broadcasting, the "talkies," radiolocation, and a host of other applications.

* * * *

In my view, therefore, we cannot overrate the importance, from the mere economic point of view, of fostering pure fundamental research. As is evidenced by its name, the Department of Scientific and Industrial Research—and I emphasise that "Scientific" comes first—recognises this. And the Government recognise that pure research must be in a large measure the responsibility of the Government and be done at the universities; but naturally we also wish to encourage industry to spend money on pure research. It is perfectly true that abroad the importance of this has been more widely recognised than it is in this country. Many great firms abroad maintain magnificent research laboratories, in which men of the greatest distinction are proud to work. Every facility is given them, and the same freedom as at a university to investigate any topic they please. Moreover, the great firms supply and support the university with their scientific facilities and maintain men to work on the purest forms of science.

In this country we have not yet quite reached this level of enlightenment. Indeed, the company over which Lord McGowan presides enjoys a singular pre-eminence in its approach to this subject. I think he will agree that the encouragement given to pure research by his firm, and the resulting contacts with the universities, have contributed in no small measure to the vision and keenness of his colleagues and staff, which have enabled them not only to expand production on standard lines, but also to develop and make quickly entirely new forms of munitions. On the other hand, we must beware of the comparisons—quantitative comparisons—which are so frequently made between what is done in the United Kingdom and what happens in the United States of America, Russia, and Germany. As the noble Viscount who initiated this debate said, it is almost impossible to draw the line between pure research and development, and development is apt to cost enormously more than fundamental research. A slight error in delimitation, a small bias in assessing what is pure research and what is development, is apt to lead to totally wrong conclusions.

I entirely agree, of course, that this country could and should do more fundamental research, but when we remember that we have only a third of the population of the United States or of the Union of Soviet Socialist Republics, and not much more than half that of Germany, and when we remember that research expenditure is, quite intelligibly, considered in those countries as an advertising point, it is clear that any endeavour to make a quantitative comparison is dangerous. After all, though the endeavour to discover the fundamental laws of nature should be regarded as an end in itself, to spend money on research is by no means an end in itself. It can only be justified if it is fertile, and to make sure that this is so is easier said than done. When a man has proved himself a competent leader he should be given every support. Nor need we fear overlapping in pure science. But it is no use merely multiplying numbers if mental capacity is lacking. As I have said, it is the policy and intention of His Majesty's Government to increase their assistance to pure research. I need scarcely add that I will welcome any developments in industry in a similar direction.

* * * *

Specialisation is, of course, inevitable, but I do not think anyone would deny the importance of the wider synthesis. The treatment of scientists in the Civil Service has been mentioned, and I must frankly admit that the Civil Service has not hitherto shown due regard for the contribution which scientists are making to the nation's welfare. I am glad to be able to say that this matter has now been reviewed, and that an investigation has been in progress to make sure that the conditions of service, pay, and prospects of Government scientific employees compare favourably with those on the administrative side of Government work, so that, among other things, interchange may in suitable cases be made easier. I hope that a definite announcement that these reforms are to be put into effect may be made before long. After all, we must preserve a sense of proportion. There are probably not more than a few dozen physicists in this country capable of evolving and developing new applications of, say, the various radio devices on which success in this war very largely depends. Everyone, I am sure, will agree that it is an anomaly to pay them on lower scales than men of equal educational status who, because they have distinguished themselves in what are usually called humane subjects, are often given war jobs of much higher status and pay than the scientist.

Strange as it may seem, scientists are fundamentally only human. Reacting against their conditions many of them have injured their case by overstating it. Many of your lordships no doubt think I have done so myself to-day; but of one thing I can assure the noble and learned Viscount, Lord Maugham, I am as much opposed as he is to the idea of a world ruled by scientific bureaucrats. Again, we must recognise that scientists are not always the easiest people in the world to handle. A man who is content to spend most of his working life pondering about the mathematical formula which expresses the relationship between the structure of the atoms and the light they emit, about how a protein molecule is built up, or a nervous impulse is propagated, may well not be sought after as a boon companion at the bar. There is much ignorance about the very nature of science, and not only in the Civil Service, but in the world at large. One noble lord, I believe, once in private conversation dismissed it contemptuously as "mere organised curiosity." Well it is quite true that that is one of its characteristics, but it is only a very superficial one. To describe it in that way is as absurd as it would be to describe religion as "organised genuflections." Anyone who did this would be deservedly castigated, for he would expose his abysmal ignorance in the very act of decrying it.

Only those who have worked among scientists realise the large fund of knowledge and accurate observation, the exact logic and vivid imagination which are required in the synthesis which reveals to the world new laws of nature. But, as all speakers have emphasised, it is putting the results of research into practice that presents one of the most difficult aspects of this question. I think this debate will have served a useful purpose if it brings the importance of research home to wider circles.

## Sixty Years Ago

### WEBB'S COMPOUND LOCOMOTIVE

IN our issues of August 3rd and 10th, 1883, we illustrated and described F. W. Webb's celebrated compound locomotive "Experiment." Some five years previously Webb had converted an old outside cylinder engine into a compound by inserting a liner in one of the cylinders in order to reduce its diameter from 15in. to 9in. The conversion was sufficiently successful to justify the building of the "Experiment" at Crewe towards the end of 1881. By the date of our description it had been in service for over a year, and had run nearly 100,000 miles, chiefly on the Scottish and Irish mails. As students of railway history are fully aware, the locomotive had a 2–2–2 wheel arrangement, the leading pair of wheels being mounted in a radial axle-box and the second and third pairs being independent—uncoupled—driving wheels of 6ft. 6in. diameter. Two outside high-pressure cylinders, 13in. in diameter, with a stroke of 24in., drove on to the rear driving axle, and a single low-pressure inside cylinder, 26in. in diameter and of the same stroke, drove the forward driving axle. The high-pressure cylinders exhausted into a pipe of large diameter running round the smoke-box, which acted both as a receiver and as a superheater. David Joy's valve motion was fitted to both the high and the low-pressure cylinders. The reversing gear of the high-pressure cylinders was independent of that of the low-pressure cylinder. Continuing a plan adopted in an earlier non-compound engine, Webb provided the "Experiment" with a form of fire-box without a foundation ring. The water space was carried round under the grate to form a water bottom to the ashpan, and a flanged opening with doors, similar to the firing door, was provided at the centre of the water bottom for the removal of the ashes.

## Triplex Process Steel Works

AMONG the many new steel works built in the United States to meet war requirements is a steel castings plant which operates on the triplex system, and is by far the largest plant employing this system. It has an output capacity of 650 tons daily, on a three-shift basis, and its product consists of castings of 25 lb. to a ton in weight for tanks, gun carriages, and other military equipment. While this process, combining cupola, converter, and electric or open-hearth furnace, is not entirely new, its present development is due to war conditions. The plant referred to consists of four cupolas, four side-blow converters, and twelve electric furnaces, although these furnaces are used also to serve other foundry operations. According to published description, the cupolas are 6ft. in diameter inside the lining, and have a rated capacity of 20 tons per hour, with a blast of 2 lb. pressure heated to 600 deg. Fah. in hot-blast stoves. Molten iron from the cupolas is delivered by 8-ton ladles to converters of 6 tons capacity, blown for about eighteen minutes by a blast of 5½ lb. pressure, with a rate of 10,000 cubic feet per minute. The blown metal averages 0·06 carbon, 0·05 silicon, 0·05 to 0·10 manganese, and 0·03 sulphur. Its temperature is 3000 deg. Fah. After the slag has been skimmed off, the metal goes to the 12-ton electric furnaces, which have an acid lining and are served by transformers of 2500 kVA. Since the furnace is utilised mainly as a mixing and storing or holding unit, its power requirements are lower than if used for melting steel. After two hours in the furnace, reaching a temperature of 3050 deg. Fah., the metal is poured into the moulds. Detailed analyses of the metal are not made public, but the metal meets the exceptionally high requirements of the specifications. If continuous operation is adopted, after a pour of 5 tons a new charge of 5 tons will be supplied from the converter to the furnace.

# The Engineer

*AUGUST 6, 1943*

VOL. CLXXVI No. 4569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## SCIENTIFIC RESEARCH

AT the end of last month the House of Lords had a very pleasant talk about scientific research. One expects the Lords to know even less, as a whole, than the Commons about science, but one does expect them to deal with that subject with full decorum. In that respect the talk to which we have referred was as perfect as could be. It had all the properties and proprieties of a pleasant chat between gentlemen across the dinner table. There were the same facile platitudes, the same deference to pundits, the same acceptance without critical examination of familiar beliefs. The only difference was that their lordships spoke consecutively and not altogether and no one asked his neighbour to "pass the port." Of all the lords who talked, only a few were able to take a broad view of the whole subject. Some of them were competent upon particular subjects, some wandered from the matter in hand, and some made statements which would not bear examination; but nearly all appeared to be convinced that Great Britain had done little or no scientific research between the wars and was miles behind other nations in all scientific respects.

Fortunately, there was amongst them one who does know a great deal about science and scientific research, at home and abroad. That was the Paymaster-General, Lord Cherwell, remembered by many as Professor Lindemann, personal assistant and scientific adviser to the Prime Minister since 1940. In his speech, made towards the conclusion of the debate, he endeavoured to dissipate some of the mist in which it seems inevitable that open discussions on research should be clouded, and removed—or at least shook—some of the misgivings about scientific research in Great Britain which lay heavily upon their lordships. For the benefit of our readers we reprint on another page much of his speech, as reported in "Hansard." It is not long since we attempted in this place to correct the common error that to science all things are possible. Lord Cherwell carried that point further by pointing out that all science is not worth while. Some economies which are "superficially real" are "fundamentally false"; many obvious improvements would involve such high capital cost that no gain would be made by adopting them. "It is not," he said, "more conservatism which prevents change. There is a form of survival of the fittest even in machinery." We have little doubt that modern economists who have a distaste for profit and loss accounts will protest that if the capital cost is too high for private enterprise, then the Government should do the work itself, whether there was economic profit in it or not. Or, alternatively, they might lean towards the suggestion made by Lord Falmouth in the same debate that the Government should establish a fund to guarantee private enterprise against loss on enterprises to which risk attached. Lord Cherwell dealt at some length with fuel research, a subject on which their lordships appeared to feel particularly strongly and ventured the suggestion that their lordships did not quite realise how much fuel research was going on. Another point which he took up cannot be too frequently stressed, for it has led in the past, and continues to lead, to odious comparisons. We must beware, he said, of the quantitative comparisons that are so frequently made between what is done in the United Kingdom and what happens in the United States and elsewhere. "A slight error in delimitation, a small bias in assuming what is pure research and what is development, is apt," he said, "to lead to totally wrong conclusions." He added the interesting item that in those countries—America, the Soviet, and Germany—research expenditure is considered as an advertising point!

Whenever scientific research is discussed, the backwardness of the United Kingdom is certain to be introduced, almost as a self-evident fact. That condemnation is due in part to our national genius for self depreciation, in part to the skill with which other nations proclaim the size of their laboratories and the expenditure upon them, and in part to the fact that like is not being compared with like. In fundamental research in all branches of knowledge this country has played and still plays a part of which it may be proud, and in what Lord Cherwell called "development research" it spends more millions than the public wots of. That work is taken by the manufacturer in his stride. He does not call it research, he does not make an annual allowance for it in his balance sheet. It bears no earmark, but it goes on just the same all the time, and is just as truly research when it is done in the workshop as when it is done in the laboratory. British engineers could not have won the position they occupy and held it against competitors were it not that they have a very sure eye for the kind of research that pays.

### Locomotive Boiler Tests

THE power of a steam locomotive is measured by the steaming capacity of the boiler, which is determined by available draught, and that in turn is a function of the pressure of the exhaust steam. But, inasmuch as the amount of combustion gas expelled from the smoke-box by the blast action of the exhaust pipe nozzle depends upon the energy in the exhaust steam and not on its weight alone, it follows that when any tests are undertaken having for their object the determination of blast pipe proportions, consideration should not only be given to the actual pressure of the exhaust, but also to its heat value, as expressed by its enthalpy. To meet these requirements the locomotive testing plant in which the engines and the boiler can be operated in the normal manner obviously is to be preferred, but such facilities are not always available, and it is when smoke-box trials are desired without a complete testing plant that the method evolved by the Engineer of Tests, New York Central System, is of special interest. For this reason the descriptive account of the means adopted, and some of the results obtained, which appeared in our issue of June 25th last, will no doubt have attracted the attention of many railway readers. They will also remember our description of certain boiler trials of a similar nature carried out some time ago by the late Sir Nigel Gresley with one of the boilers as fitted to his "Pacifics."

The large amount of power absorbed by the blast pipe in providing the steam required is fully appreciated, and during recent years much thought has been given to the design of blast pipes and chimneys, and many investigations have been carried out with the object of reducing the exhaust pressure for the draught required. But standing tests like the "Selkirk," now under notice, do not strictly conform to conditions in actual service, or to those present when such trials are made on a stationary testing plant. In the first place, the steam is exhausted in the form of a continuous jet as opposed to the intermittent pulsations which result from its passage through the cylinders, and though at high speeds no doubt the flow of the exhaust is for all intents and purposes continuous, this difference may be held by some to operate against the value of this method of arriving at the design and proportions of the blast pipe and chimney arrangement. In

this connection the opinion has been expressed that three-cylinder engines, giving six exhausts for each revolution of the driving wheels, and those of the four-cylinder type with the 135 deg. crank setting, giving eight exhausts per revolution, provide a better and more efficient smoke-box action than do normal two-cylinder engines. It is held that the blast action being more continuous, the smoke-box vacuum is more nearly constant, and that there is less tendency for the fire to lift and hence fewer spark losses. Others, on the other hand, do not share that view. A further point in connection with the experiments, as made by the New York Central, is the necessity for securing reliable data as to the actual state of the exhaust steam that may be expected to exist at different rates of working under actual operating conditions on the road. This information must also relate to the particular locomotive, the blast pipe design of which is to be invsetigated. This condition appears fundamental, and again emphasises the value and importance of a complete testing plant.

Despite these objections, the testing system designed by the New York Central authorities for making their investigations is of considerable interest and displays great ingenuity. It is serviceable also because it points to the significant fact that we still seem to be very much dependent upon trial and error for determining quite important dimensions of the steam locomotive—the size of the blast pipe and its relationship to the form and size of the chimney. That problem is amongst the many which we may hope to see solved scientifically when the British Locomotive Testing Plant, begun before the war, is in due time completed.

## Letters to the Editor

*(We do not hold ourselves responsible for the opinions of our correspondents).*

### MR. P. C. DEWHURST'S ENGINE

SIR,—Knowing by experience that the publication of a new form of locomotive in THE ENGINEER is likely to produce an interesting discussion, I hope that will be the case in the present instance.

Mr. Dewhurst's design throws a good deal of weight on the bogie, but at high speeds this effect would be relieved by what I call "trim." I see he cuts up the frames over the trailing bogie wheels, a practice which I have shown to be unnecessary.*

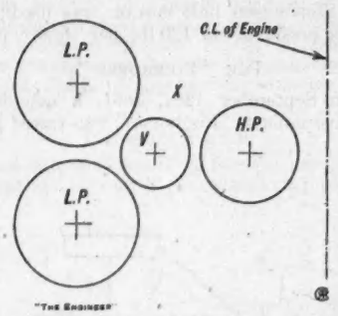
I am afraid the thrusts on the double crossheads would not be equal; the upper cylinders would provide the lion's share of the power, owing to being closer to the valve. At high speeds there would be little or no lead in the lower cylinders. If all four drove the same axle, an arrangement suggested by Mr. Dewhurst, but not shown, a much simpler engine would result, and if a cross between a Vauclain and a "Prospero" valve could be schemed, the beautiful symmetry shown below might be achieved. In this case bar framing to the front of the engine would be necessitated.

Alternatively, the valve could be located at X, which would give unlimited room for it and simplify the frame design (a plate frame could then be used), but the symmetrical and direct valve passages would be lost. The problem of designing a valve would be an interesting one.

* See "The Motion of Railway Vehicles on a Curved Line," page 25.

The Vauclain is for compound engines, but synchronised pistons; the "Prospero" for simple engines, with opposed pistons; so neither is directly applicable. Crossed ports, suggested by Mr. Dewhurst as a possibility, are an abomination and quite contrary to modern streamline ideas.

My valve was far from being the failure that it might have been inferred to be from the fact that it was only used once. The "Prospero," originally built in 1907, ran for many years after having been converted to my system in




1915, without alteration. I have a report of August, 1920, which gives the coal consumption as 62·7 lb. per mile and the average mileage between repairs in shops as 58,365; whereas the corresponding figures averaged for forty-nine engines of the same class not converted were 68·1 and 46,666. The fact of the matter was that after my friend Mr. Bowen Cooke died, Crewe lost interest in it, and I was not allowed to have another try.

Mr. Dewhurst's suggestion about the platforms is a brilliant one.

C. F. DENDY MARSHALL.

Guildford, July 30th.

### AUTHORITY IN THE FACTORY

SIR,—Can nothing be done to prevent the whittling down of the authority of people in a supervisory capacity?

In a factory handling highly inflammable material, a foreman observed a crane driver smoking in the control cabin of a loading bay crane. The offence had always been regarded as of a serious nature and disciplinary action took the form of suspension for three days. The man (who chanced to be a shop steward) immediately appealed to the Ministry of Labour tribunal, and when the case was heard the official ruling directed that the man had been wrongfully suspended and ordered his employer to pay full wages for the time lost.

The official view was that the crane driver's word was as good as that of the foreman, and that as the driver had denied that he was smoking—well, of course, he was not smoking!

In future it would seem that a witness must be forthcoming, but where can a witness be found? Obviously, a fellow-workman will not testify, and any member of the supervisory staff will be considered biased.

The crane driver's manner is now insufferable, and the exasperated foreman vows that he will be blind to future offences.

What hope is there for a "brave new world" after the war? E. B. PARKER.

Wirral, Cheshire, July 27th.

## Obituary

### JOHN BURDON

IT is with regret that we have to record the death at Bedford, after a short illness, of Mr. John Burdon, formerly of Sidcup, Kent, in his seventy-ninth year. Although Mr. Burdon had been in retirement for some while, he was for a very long period actively associated with the firm of Worthington-Simpson, Ltd., in the development of pumping plant for waterworks and sewage disposal works, both at home and abroad. As chief draughtsman and subsequently chief engineer to the company, he was responsible for many important contracts which were carried through under his direction. Mr. Burdon entered the service of Worthington-Simpson, Ltd., in the year 1889 as a draughtsman, and remained in the company's employment until 1932, when he retired. He was elected an associate member of the Institution of Civil Engineers in the year 1896 and was also a Whitworth Scholar.

### FREDERIC SHELFORD

WE have learned with regret of the recent death in South Africa of Captain Frederic Shelford, late consulting engineer for the West African and other Government railways. Born in 1871, he was the son of Sir William Shelford, and was educated at Westminster School, Dulwich College, and the City and Guilds Engineering College. He took his B.Sc. degree at London University in 1892, and was later engaged in the construction of various railway and water supply works in this country, as well as carrying out a great deal of railway consulting work for the Crown Agents for the Colonies. In 1917 Shelford became a barrister and practised at the Parliamentary Bar. During the last war he served as a Captain in the Royal Marines. He travelled a great deal and wrote on "Railway Surveying in Tropical Forests" and "Pioneering." Articles from his pen on these and kindred subjects appeared, it may be recalled, in these columns a good many years ago.

### BOOKS RECEIVED

*Gravity Diecasting Practice.* By G. W. Lowe. Maidenhead: Percival Marshall and Co., Ltd., Cordwallis Works. Price 3s. net.

*Elementary Surveying.* By A. L. Higgins. London: Longmans, Green and Co., Ltd., 43, Albert Drive, S.W.19. Price 6s. net.

*Supplement to the Factories Act, 1937.* By H. Samuels. London: Stevens and Sons, Ltd., Chancery Lane, W.C.2. Price 5s. net.

*The Fireman and his Pressure Gauges.* By A. J. Mann. London: Lomax Erskine and Co., Ltd., Aldwych House, Aldwych, W.C.2. Price 2s. net.

*Industrial Recruitment and Training.* London: National Institute of Industrial Psychology, Aldwych House, Aldwych, W.C.2. Price 1s. net.

*Steam Boiler Year Book and Manual.* Edited by S. D. Scorer. London: Paul Elek (Publishers), Ltd., Africa House, Kingsway, W.C.2. Price 30s. net.

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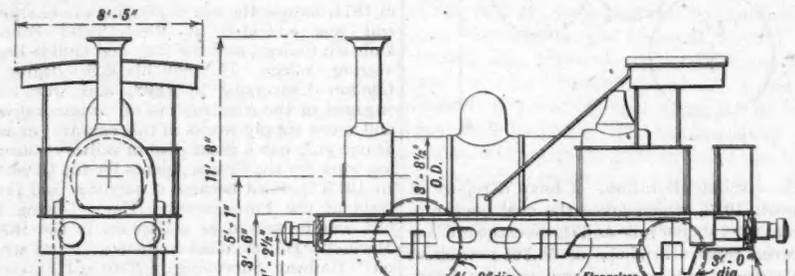
# First Steam Engines in South Africa

*(From Our South African Correspondent)*

SEEING the importance of bread, and the necessity of flour for its manufacture, it is not surprising to find that the first steam engine to reach South Africa was a flour mill, which was imported by a Cape Town firm in 1831. So successful was the venture that the next two decades saw the arrival of many more such units in various parts of the country. The next development in the industrial use of steam came in 1854, when a printing firm in Cape Town introduced steam power and cylinder presses which at one stroke left the previous methods far behind.




S.A. LOCOMOTIVE OF 1859

In 1855 the sugar industry was revolutionised by the introduction of steam-driven machinery for crushing cane and converting the juice into sugar. In 1857 steam was harnessed to the service of the timber industry at a mill at the beach end of Field Street, Durban. Of 2½ H.P., it drove one pair of stones, a crusher, and a circular saw that was equal to cutting a 9in. deal into planks. This engine afterwards drove a cotton gin, the first in Natal, where an unsuccessful attempt to establish the cotton industry was being made.

A great advance in the use of steam and an epoch-marking event in the history of the industrial, commercial, and general development of South Africa came in 1859, almost simultaneously in Durban and Cape Town, with the advent of railway transport. The Durban Point Railway was actually in operation a few months before the inauguration of a service from Cape Town, but the former was merely a connection between town and docks of a couple of miles at most. The Cape Town line ran to the town of Wellington, as a first instalment, and to-day has its terminus at Pretoria, a distance of over 1000 miles.

Cape Town's first locomotive was built in 1859 by Hawthorn, of Leith, Scotland, and worked on the original South African broad-gauge line (4ft. 8½in.). It arrived at Cape Town in the brig "Charles," of about 200 tons, in September, 1859, and had to be dismantled before it could be brought ashore in lighters. After the boiler had been safely landed the wheels were affixed and, as there were no rails, four deals were placed on the jetty. The engine ran between Cape Town and Wellington (35 to 40 miles) during 1860 and 1872. In 1934, many years after it had been replaced by more modern types, it was declared an historic monument and may now be seen on the Cape Town Railway Station.

The wheel arrangement is of the 0-4-2 type with 4ft. diameter coupled wheels, and it has been ascertained that the total weight is 14 tons ("Construction of Railways in the Cape of Good Hope," by James Bisset, civil engineer, 1868). It is probable that this is the weight empty. The cylinders, 10in. by 18in., were arranged inside the frames and the Stephenson link motion was used; the boiler pressure was 120 lb. per square inch.

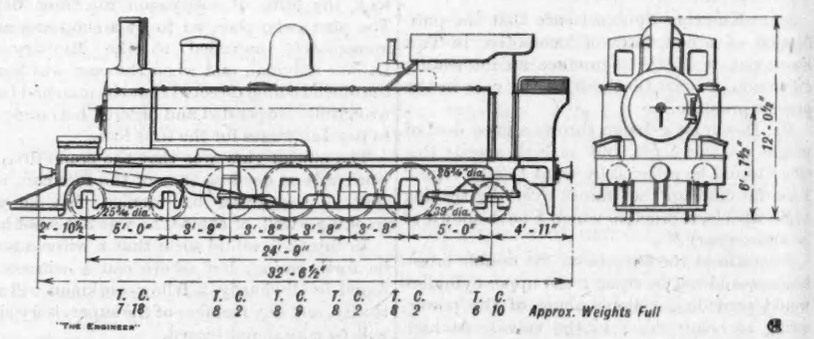
### The "Firehorse"

On September 12th, 1861, a new locomotive named "Firehorse" was tested in a run of 10–12 miles from Cape Town, pulling some coaches which had been imported from England. Unfortunately, however, there was a hitch, when it was found that the wooden platform at the station was too high for the floor of the coaches and had to be taken down. It was quite common in those days for a train to stand still for a long time while the engine was making steam before ascending a gradient.

The first two steam engines to be made in South Africa appeared in 1870. One was built by the master engineer at Simonstown, and the other was turned out at the Albany Ironworks, Grahamstown. It was a condensing 20–25 H.P. engine, with 3ft. stroke and 18¼in. cylinder.

How the use of steam has increased since the first locomotive started running in 1860 can be gauged from a few facts. To-day the South African Railways have in service about 2200 locomotives, having tractive forces ranging from about 50,000 lb. in the case of units of medium power locomotives up to as much as 80,000 lb. in the case of the great "Garratts," with their huge weights averaging, over the whole class, about 170 tons each. It may also be mentioned that there are still in service, and apparently in robust health, locomotives that were first put on the main lines as far back as 1890, while some engines relegated to unimportant branches are said to date still further back. Practically all these locomotives run on the 3ft. 6in. gauge, which is the standard for the South African Railways. There are among the "fleet" of locomotives in service to-day British, American, and German makes. British makes constitute the large majority and one would say that the engines from Scottish locomotive works hold the record for longevity. Only this month one saw an engine near Cape Town hauling a long line of trucks laden with great baulks of timber and other heavy goods. The nameplate bore the date 1901, and the engine was steaming steadily along and evidently in first-class condition and looking not a bit like a veteran of forty-two years. She was a fine testimonial to the Glasgow locomotive works at which she was turned out.

Among the locomotives placed in service about the year 1888, and still doing useful work, are a few class "A" engines built by Dubs, Glasgow. These engines were imported by the Natal Railways for the heavy goods traffic of that period. They are side-tank engines with a wheel arrangement of 4-8-2 type, a tractive effort of 18,670 lb. (75 per cent. B.P.), and Stephenson's link motion. This class of engine constituted an entirely new type of locomotive for 3ft. 6in. gauge lines in Natal. The cylinders, 17in. diameter by 21in. stroke, are arranged outside the engine frames. The coupled wheels are 3ft. 3in. diameter, the total wheel base being 24ft. 9in., of which 11ft. is that of the coupled wheels. The boiler, 10ft. 10½in. between tube plates, with 178 tubes, 1¾in. external diameter, has a tube heating surface of 888 square feet, the total heating surface being 978 square feet. The grate area is 16 square feet and the pressure in the boiler 160 lb. per square inch. The tank capacity is 1062 gallons, while 2½ tons of coal can be carried. The total weight of engine in working order is 47 tons 3 cwt., of which 32·75 tons are carried on the coupled wheels. It may be mentioned that until recently a few of these engines had flangeless tyres on the leading coupled wheels for working on special lines.




SIDE TANK LOCOMOTIVE OF 1888

### The First Iron Ship

While 1860 was a year of great significance in the transport history of South Africa, it is equally true that the year 1840 was in no way less significant in the shipping history of South Africa, for it was in that year that a ship constructed of iron first rounded the Cape of Good Hope. This ship was the "Nemesis," a frigate of the East India Company, and built under a veil of secrecy at Birkenhead in 1839 by the famous firm of

Laird's. Her displacement was only 700 tons, her length 184ft., beam 29ft., while the draught was 11ft. The ship was designed with a very flat floor and was divided into numerous water-tight compartments by means of iron bulkheads. There was no keel in the true sense of the word, but two movable centre boards were fitted, one forward and one abaft of the engines.

She was propelled by paddle wheels, each of which was driven by a steam engine of 120 H.P. The engines were made by Forrester, of the Vauxhall Foundry, Liverpool. The thin single funnel was placed amidships, close to the main mast. The "Nemesis" was really a sailing vessel, the steam engines being auxiliary to the principal means of motive power, the sails. She was rigged with two masts as a brigantine. The "Nemesis" left Liverpool in March, 1840, but ran aground early in the voyage. She was refloated and towed to Plymouth, where the damage was repaired. When made seaworthy she left for Table Bay, where she arrived (after calling at Madeira early in April) two months later. At Cape Town she made a stay of some days and became the centre of attraction for all the inhabitants and many from other towns and villages. The "Nemesis" then proceeded to China and traded for years for the East India Company. During the blockade of Canton she formed a temporary addition to the British fleet, and therefore the East India Company claimed the honour of having been the first body to use iron vessels for the purpose of war. But the "Nemesis" was not a liner on the Cape route, or even a regular caller at Union ports, the Chinese trade being much more important in those days.

### THE PIONEER LINER

The pioneer liner on the London to Cape Town run, the steamship "Dane," did not start on that service until 1857 and was only of 530 tons register. The trade, however, steadily developed and the pioneer of the present Union-Castle Line was built in 1863. She was the "Stirling Castle," a full-rigged sailing ship and had a tonnage of 1165. The expansion which has taken place in the over-sea trade of South Africa can be gathered from the fact that when, three-quarters of a century later, the company put into the service a second "Stirling Castle," she had a capacity of 25,550 tons gross, being over 5000 tons greater than the "Warwick Castle," until that time the "Queen" of the Union-Castle fleet. The length of the "Stirling Castle" is 725ft., moulded breadth 82ft., and loaded draught about 32ft. Her engines, of 24,000 B.H.P. and 28,500 I.H.P., made her at that time the most powerful motorship under the British flag and the third most powerful in the world. The company in a couple of years surpassed the "Stirling Castle" in size, though not by much, with the "Cape Town Castle," and it is understood that the company was planning yet bigger mail boats, but the war has held them up. The "Stirling Castle," it may be added, is a twin-screw motorship and cost approximately £1,250,000. She was built by Harland and Wolff, of Belfast, who have built all the latest Union-Castle liners. She is said to possess a speed of quite 24 knots and to have shown it often.

It may be mentioned in conclusion that in 1938 the value of imports into the Union exceeded £105,000,000. In the same year the value of exports amounted to £78,973,042, a decline of £44,937,643 compared with the previous year. Most of the decrease was the result of the adoption of a new policy in respect of gold, under which gold for banks and firms abroad was not shipped to them, but retained by the Reserve Bank of South Africa, earmarked for them. This avoided risks in the unsettled state of things. The extent to which the gold mines of South Africa and the municipalities are indebted to steam for their development would be of equal interest to the contents of this article and may be dealt with later.

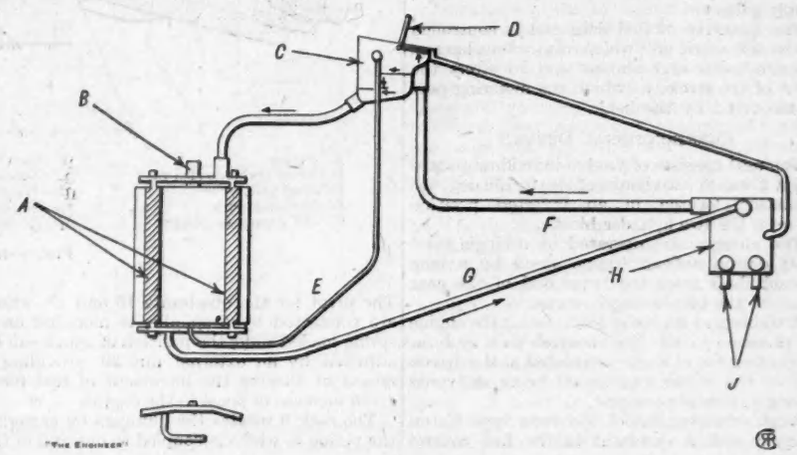
# "Jumo" Aero-Engines—Fuel Injection

THE Ministry of Aircraft Production has compiled a very detailed report on German aircraft engines "Jumo" 211 A, B, and D. From this report we take the following description, abridged, of the injection system and pumps.

### INJECTION SYSTEM

*Fuel Supply System* (*Fig.* 1).—Fuel, supplied at approximately 10 lb. per square inch pressure from the Junkers oscillating cylinder service pump, is led through a deaerator to the end of one of the injection pump duplicate fuel galleries, which are connected by an upward-cooping pipe, excess fuel being returned from the other end of the galleries *vid* a pressure relief valve in the service pump to its suction port. Any air in the galleries or loop escapes through a pipe into the deaerator and thence into the fuel tank; the relief valve is pressure balanced to the deaerator vent.

*Working of the Injection System.*—The injection pump deliveries are controlled by an automatic unit, proportionally to the pressure and the inverse square root of the absolute temperature of the air in the chamber of a controlling capsule. This air is circulated from the engine induction pipe. Each plunger delivers the fuel through two spring-loaded non-return valves to the atomiser nozzle between




A—Injection pump fuel galleries
B—Pump drive
C—Deaerator
D—Air vent to fuel tank
E—Air vent pipe
F—Main delivery pipe
G—Excess fuel pipe
H—Service fuel pump
J—From fuel tanks

FIG. 1—INJECTION SYSTEM OF JUMO AERO-ENGINE

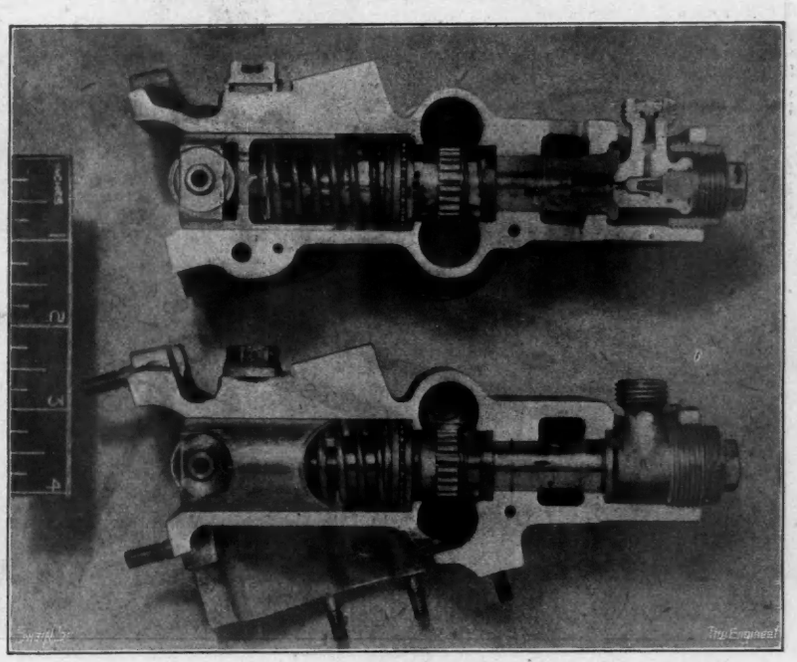


FIG. 2—INJECTOR PUMP

the inlet valves in the side of the cylinder head.

The fuel charge delivered is automatically controlled by a single capsule operating a piston type valve which admits oil under pressure to the vane type piston of a servo unit connected by racks and pinions to the pump delivery controlling mechanism. An extra manual control, provided for enrichening or weakening the mixture, was found to be locked by wire. The control unit, which is an essential part of the injection pump, is fully described in a separate paper.

*Operation of the Pump.*—When the plunger is within approximately 0·052in. of the B.D.C. position the fuel enters the pump barrel through a specially shaped port which remains open for 178 pumpshaft degrees. Fuel is therefore spilled through both this port and a second circular port until both are closed by the ascending plunger, when delivery commences (104 deg. B.B.D.C. engine suction stroke). Delivery ceases when the inclined edge of the metering port is uncovered by a helix cut in the plunger, after which the fuel is displaced back into the supply gallery.

The quantity of fuel delivered is controlled by the automatic unit which rotates the plungers through racks and pinions and so alters the point of the stroke at which the metering port is uncovered by the helix.

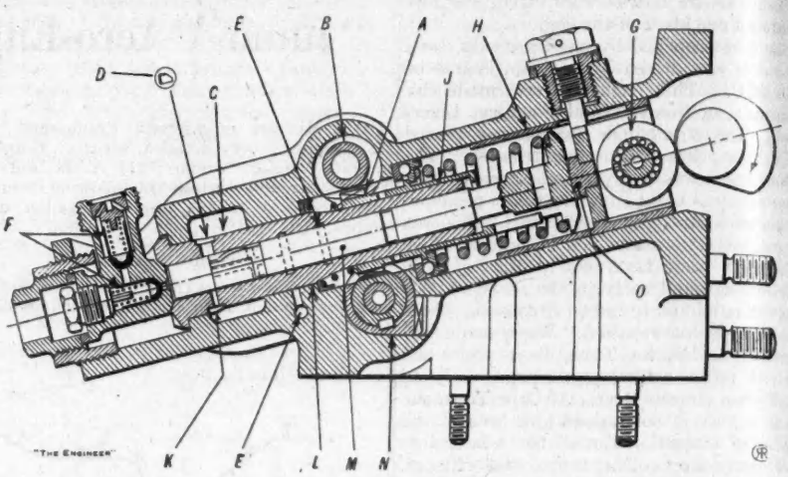
### Constructional Details

The unit consists of twelve individual pumps (Figs. 2 and 4) (two banks of six) in 150 deg. vee formation located in an inverted position between the two cylinder blocks.

The plungers are operated by a single camshaft driven at half engine speed by a long splined shaft from the lower end of the gear train for the oil scavenge pumps.

A treble gear oil pump for boosting the engine oil pressure to the fuel control unit and for lubricating the plungers is situated at the driven end of the camshaft, the oil being delivered through internal passages.

Angular movement of the vane type piston integral with a quadrant in the fuel control unit is transmitted to the plungers by racks, quadrants, and pinions. Referring to Fig. 4, the quadrant on the fuel control unit engages with the rack 14, which is integral with the rack 15; this latter rack engages quadrant 16, transmitting movement through quadrant 17, rack 18, and quadrants 19 to the main racks 9.




A—Pinion
B—Short spring-loaded rack
C—Fuel gallery
D—Metering port
E—Oil supply to plunger
F—Non-return valves
G—Needle bearing cam follower
H—Tappet
J—Sleeve
K—Additional circular port
L—Barrel
M—Plunger
N—Main control rack
O—Hardened button

FIG. 3—INJECTOR PUMP

The pivot for the quadrants 16 and 17, which are connected by a spindle, is mounted on a spring-loaded slide, the position of which can be adjusted by an external nut 20, providing a means of altering the increment of fuel for a given increase of boost in the engine.

The rack 9 rotates the plungers by engaging the pinion 6, which is coupled to one end of the sleeve 5 by two 90 deg. vee serrations, the pinion being loaded on to the sleeve by a conical spring (Fig. 3). At the opposite end of the sleeve a projecting split spring tab engages a slot in the bottom of the plunger. Thus, in the event of a plunger seizing control of the remaining plungers is not affected, the vee serrations of the seized plunger being forced out of engagement.

In order that the fuel delivery from each pump may be adjusted to the requirements of individual cylinders, the rack 9 is built of six short movable racks secured in a steel tube, the teeth of the racks projecting through slots cut in the side of the tube. Feathers riveted to the

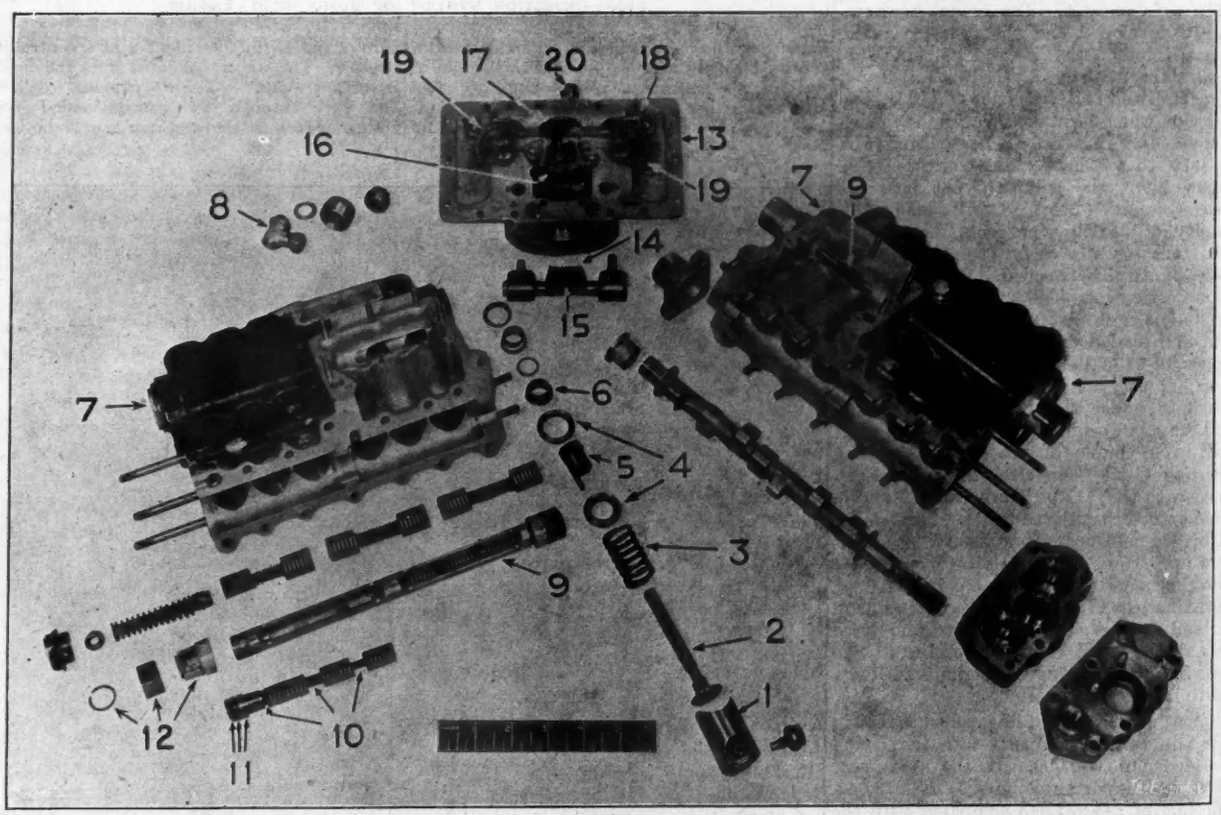



FIG. 4—DIS-ASSEMBLED PARTS OF INJECTOR PUMP

tube bore prevent rotation of the racks. The latter are adjusted axially by micrometer screws fitted one inside another 10, (Fig. 4), three being operated by serrated heads at each end of the tube. The minimum rotational adjustment of the plungers is approximately 0·13 deg. The racks are held in the tube by screwed-on end caps, which are open to allow access to the serrated heads of the adjusters. Locking collars, with two sets of three internal serrations diametrically opposite, which mesh with the external serrations on the heads of the adjusters, are guided on the end caps and locked by circlips. The racks are closed by oil-tight screwed caps.

Opposite each main control rack 9 (Fig. 3 and Fig. 4) are six short racks, each engaging with a plunger pinion 6. Helical springs placed between 1 and 2, 3 and 4, 5 and 6 separate every other pair, and eliminate backlash between the pinions and main control rack. Backlash in the racks and quadrants between the main racks 9 and the control unit is obviated by two further springs introduced between a housing cap nut and one end of each secondary rack. The loading of these springs is in the direction of the rack movement for maximum delivery.

The two banks of pumps are held together by studs with special serrated nuts of cylindrical shape instead of the usual hexagon form. No locking device is used, while the studs, unlike the majority on the engine, are neither shouldered nor turned down to the thread core diameter.

*Camshaft and Tappets.*—Six cams are arranged integrally at intervals of 60 deg. around the hollow shaft, the injection order for one bank being 1-4-2-6-3-5. The correct order for the complete pump is obtained by the 150 deg. vee formation of the two banks. The shaft is carried by three light alloy bearings. Each tappet is manufactured from the solid. A pressed-in highly polished hardened steel button is provided to bear against the plunger. Seven holes are drilled through the tappet face to allow a flow of lubricating oil. A roller running on needles is used as the cam follower. These needles roll on a pin which is a push fit in the tappet and is secured by two circlips. The tappet is located by a pin, screwed through a steel insert in the housing, the necessary slot being milled in the tappet skirt.

*Plunger.*—The plunger is machined with two diametrically opposite helices, one for metering the fuel and the second probably to eliminate side thrust. The second helix, together with a passageway drilled in the plunger serves also for returning fuel rapidly from the pump chamber to the gallery after cut-off. The plunger hole is drilled axially for 11 mm. from the top, where it meets a transverse hole drilled through the reduced diameter at the helix. An oil-retaining groove is cut about two-thirds of the way down the rubbing surface for lubrication purposes.

*Barrel.*—The barrel has two ports, one specially shaped for metering the fuel and the other a circular hole to assist the flow of fuel to and from the pump chamber. The former port is an irregular five-sided hole with the longest side parallel to the plunger helix, and is counterbored on the outside. Its particular shape allows a quick return of the fuel to the inlet gallery after cut-off, and so prevents excessive dribbling from the open type injection nozzles.

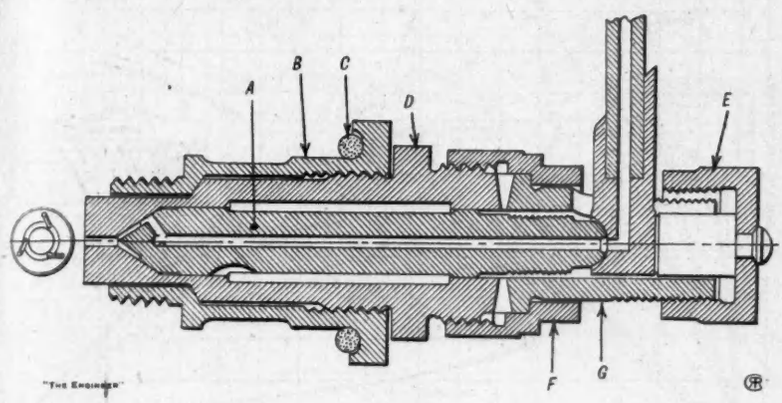
Two grooves are machined in the barrel. The lower one is supplied with oil direct from the booster pump through a non-return valve for lubricating the plunger, while the top groove communicates with the fuel gallery. The latter groove, which is approximately 0·6in. below the bottom of the plunger stroke, acts as a relief passage for any fuel forced down the clearance between the plunger and barrel during injection, this fuel taking the easier path back to the gallery rather than continuing down the side of the plunger and mixing with the lubricating oil.

The barrel is a press fit in the housing and is located longitudinally by a shoulder at the top. The shoulder seats in a recess in the housing.

*Delivery Valves.*—Two non-return valves in series, clearly shown in Fig. 3, are contained in the steel right-angle delivery housing, the leg of which seats on a tapered face at the top of the barrel. The valves themselves are small spring-loaded hollow ball-ended cylinders; the spring of the one axial with the plunger is held by a screw, while that of the other is located by a steel button held by a circlip. The button forms the seat for the fuel line union nipple.

*Lubrication.*—Oil at engine service pressure (60 lb. per square inch) is boosted by the treble gear pump for operation of the servo, the return oil from which, together with that which escapes through the servo by-pass valve, is led into the camshaft chamber to lubricate the cams, followers, lower part of the plungers, the operating racks, and the front and centre camshaft bearings. This oil escapes through a duct in the housing of the front camshaft bearing bush, *viâ* the hollow camshaft and driving spindle back to the engine wheel case.

Additional oil is supplied directly from the booster pump to the rear camshaft bearing bush housed in the booster pump casing, and also through non-return valves to the upper parts of the plungers. The oil flows to the plunger through a very narrow groove cut on the inside of each barrel housing, and connected by a small hole to another groove in the bore of the barrel. A duct in the booster pump cover communicates with the outside of the driving spindle, and drains the annular space between this spindle and its protecting sleeve.




A—Nozzle pin
B—Adaptor
C—Rubber ring
D—Nozzle body
E—Cap nut
F—Union nut
G—Banjo sleeve

FIG. 5—INJECTOR

### INJECTION NOZZLE

The nozzle (Figs. 5 and 6) is of the open type, no pressure valve being fitted.

Fuel is delivered through a steel pipe (5 mm. outside diameter by 1·5 mm. bore) to an elbow seating 6 (Fig. 6), on the hemispherically ended drilled nozzle pin 3 which seats at its other end on a 60 deg. face formed in the nozzle body 2. Three skew slots are provided in the face of the pin converging into a 1·17 mm. diameter discharge orifice, 4·25 mm. long, through which the spray emerges in the form of a 90 deg. hollow cone. A screwed radially serrated banjo sleeve 4 slotted to take the elbow fitting 6, and held in another set of serrations in the body by a union nut 5, eliminates bends in the fuel line

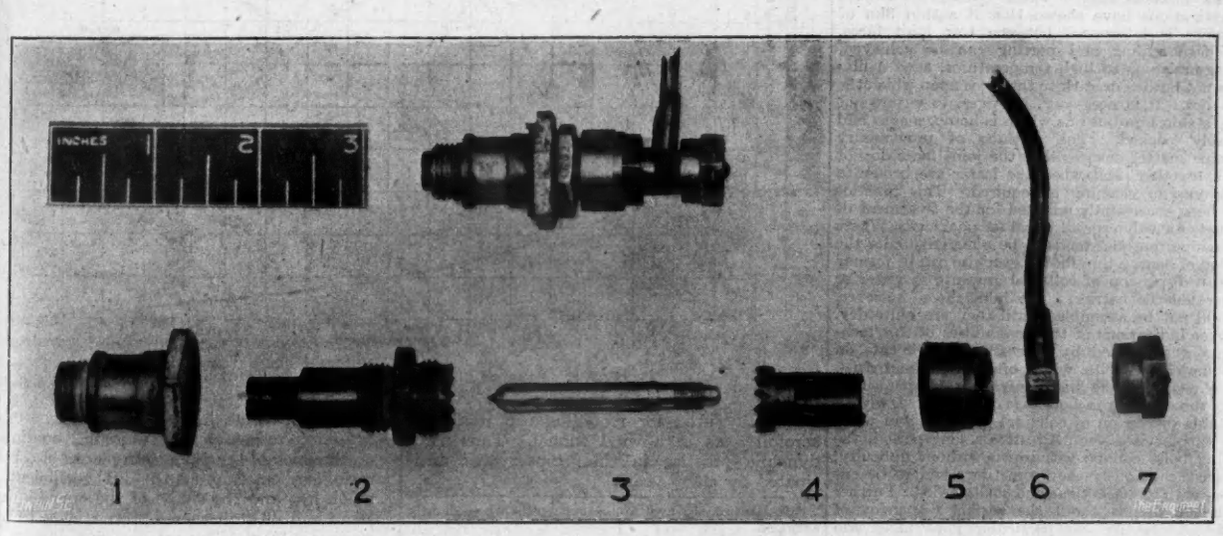



FIG. 6—ASSEMBLY AND DETAILS OF INJECTOR

approach to the nozzle. A cap nut 7 screws on to the sleeve and holds the elbow on to the nozzle pin.

No provision is made in the 221A (1) unit to correct the quantity of fuel injected for changes in exhaust back pressure, but on later type 221B, Series 1, and 211D, Series 1, engines, a second capsule is fitted in the capsule chamber between the existing capsule and the capsule adjustment. The interior of this second capsule is vented to atmosphere, and the response to the relative air pressure inside and outside (atmospheric) the chamber thus moves the oil servo valve to correct the injection pump delivery for varying differences between boost and exhaust (assumed atmospheric) pressure in the engine, due to changes in altitude, below the "rated height." As a further modification, the capsule chamber is made of bakelite instead of magnesium alloy. The effect of this would be to reduce the heat loss from the chamber, and result in a temperature control more nearly corresponding to the inverse square root of the induction pipe air temperature.

The following materials are used :—

| | | |
|---|---|---|
| Housing : | | |
| Pump ... ... ... ... | | Aluminium-rich bearing alloy, 6 per cent. iron |
| Control unit ... ... | | Magnesium alloy |
| Camshaft ... ... ... | | Nickel-chromium case-hardening steel (C 0·14 per cent., Si 0·3, Mn 0·78, Ni 0·42, Cr 0·98, Mo 0·05 per cent.) Case-hardened on the cams to a depth of 0·055in. |
| Vickers hardness Nos. | | Cam face, 770 average<br>Cam bearing surface, 790 average<br>Shaft and core, 280 average |
| Weight ... ... ... | | 1 lb. 3 oz. |
| Dia. of cam base circle | | 0·670in. (17 mm.) |
| Lift of cam base ... | | 0·325in. (8·25 mm.) |
| Width of cam face ... | | 0·437in. (11·1 mm.) |
| Camshaft bearings ... | | (3 off), aluminium-rich bearing alloy, 6 per cent. iron |
| Tappet ... ... ... ... | | Weight, 3 oz. |
| Plunger ... ... ... ... | | Nickel-chromium case-hardening steel (C 0·15 per cent., Si 0·3, Mn 0·36, Ni 3·63, Cr 0·84 per cent.) Case-hardened at the surface to a depth of 0·03in. |
| Vickers hardness Nos. | | Surface, 600 to 700<br>Core 400 |
| Weight ... ... ... | | 1·75 oz. |
| Barrel ... ... ... ... | | Plain carbon case-hardening steel (C 0·17 per cent., Si 0·25, Mn 0·35, Ni 0·16, Cr 0·06, S 0·024, P 0·014 per cent.) Case-hardened on the outside and inside surfaces to a depth of 0·02in. |
| Vickers hardness Nos. | | 850 to 900 |
| Weight ... ... ... | | 2·0 oz. |

NEW GREEK DESTROYER.—H.M.S. "Bramham," a destroyer of the "Hunt" class, has recently been presented by the British Government to the Royal Hellenic Navy. She has been renamed "Themistocles."

PREVENTING JOINTS FROM STICKING.—Recent investigations have shown that if a thin film of graphite is interposed between tow joint faces, adequate sealing and parting can be achieved. Being resistant to high temperatures, such a film does not harden or stick to the faces upon which the film lies. It is necessary, however, to ensure not only a thin film but one which is homogeneous and densely packed. The absence of unnecessary organic matter ensures that the joint faces do not stick together, and when the latter are broken a minimum of cleaning is required. This practice has been successfully adopted for the treatment of gaskets for valve spindles and for packings. Where a packing material tends to be adherent under the action of heat, a thin film of graphite can be formed with a dispersion of colloidal graphite in water or other volatile carrier. The joint faces, however, should not be assembled until they are quite dry. Earlier indications of the possibilities of this technique were offered by successful experiments on turbine casing bolts, which often seized and stuck as a result of the high prevailing temperatures. The threads of the bolts are now treated with a suitable dispersion of colloidal graphite, and when the turbine is dismantled after a long period, the casing bolts can be withdrawn without difficulty, whereas previously they sometimes had to be cut away with oxy-acetylene and so discarded. Further technical details about the correct dispersion of colloidal graphite for particular joint faces and materials can be obtained from E. G. Acheson, Ltd., 9, Gayfere Street, Westminster, London, S.W.1.

# Steering Experiments*

By R. W. L. GAWN,† R.C.N.C., Member of Council

(*Continued from page 93, July 30th*)

RESULTS of experiments on planes afford some useful information concerning the variation of normal force with shape, proportion, and angle. Figs. 5 to 7 show curves of lateral force coefficient (*i.e.*, "lift") and fore and aft force coefficient (*i.e.*, "drag") on planes of various shapes and proportions inclined to the direction of motion at various angles, obtained from experiments carried out at the Admiralty Experiment Works, Haslar, under Mr. R. E. Froude's directions more than forty years ago. The non-dimensional coefficients to which the results are plotted are the same as those now universally used for recording the results of aerofoil tests in a wind tunnel. Thus aerodynamic practice in this respect was anticipated by many years.

A wide range of proportions of outline is covered by the curves, the smallest being 1 to 3 and the largest 4 to 1, expressed as a ratio of major to minor axis for elliptical planes and from 1 to 2 and 2 to 1 respectively with rectangular planes. The curves also include the forces deduced from Rayleigh's theoretical formula for infinite aspect ratio. It is instructive as regards the bearing of these results on steering to divide the curves into three main regions :—

(*a*) *Angle of Incidence Less than* 10 *deg.*—The lift coefficient on the planes of larger aspect ratio is proportional to the angle of incidence consistent with Rayleigh's formula, but the magnitude of the lift coefficient is about 2½ to 3 times that given by the formula. If it could be assumed that the formula correctly interprets the face pressure, then this comparison indicates the increase of lift due to reduction of pressure or "suction" on the back of the plane. In planes of aspect ratio less than unity the lift coefficient is much less and the shape of the curve is less steep and of a character proportional to the angle squared. The sequence of change of lift with aspect ratio can be regarded as

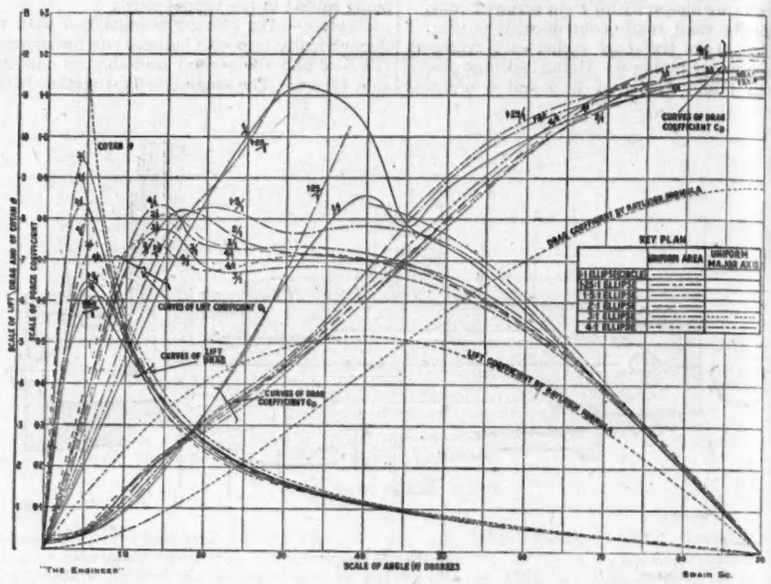



FIG. 5—*Forces on Elliptical Planes of Largest Aspect Ratio*

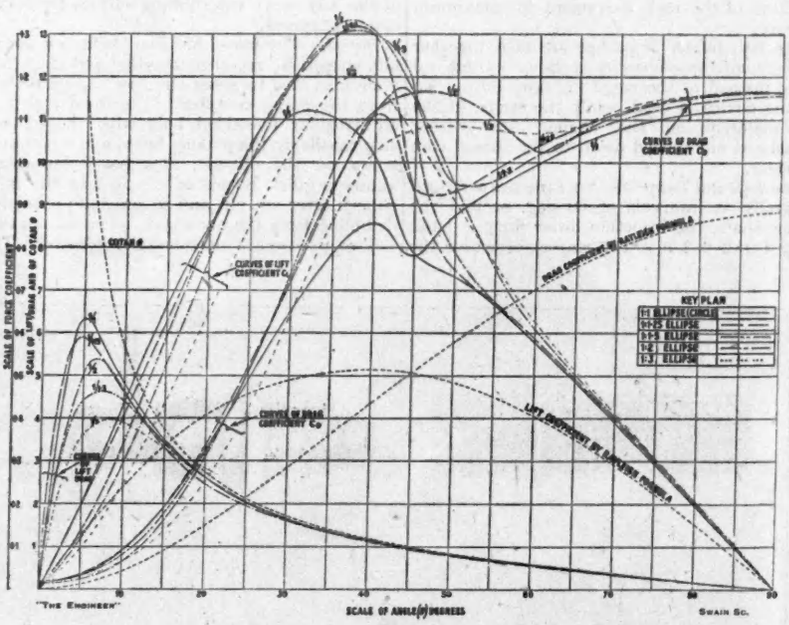



FIG. 6—*Forces on Elliptical Planes of Smaller Aspect Ratio*

* Institution of Naval Architects, April 15th.—Slightly abridged.

† Superintendent, Admiralty Experiment Works, Haslar.

fairly consistent with the formula, since the theoretical solution is for a plane of infinite aspect ratio.

(*b*) *Angles of Incidence from* 60 *deg. to* 90 *deg.*—The lift coefficient is naturally small, and most interest concerns the drag coefficient. There is little difference between the various planes, the magnitude of the force being 30 to 40 per cent. greater than by

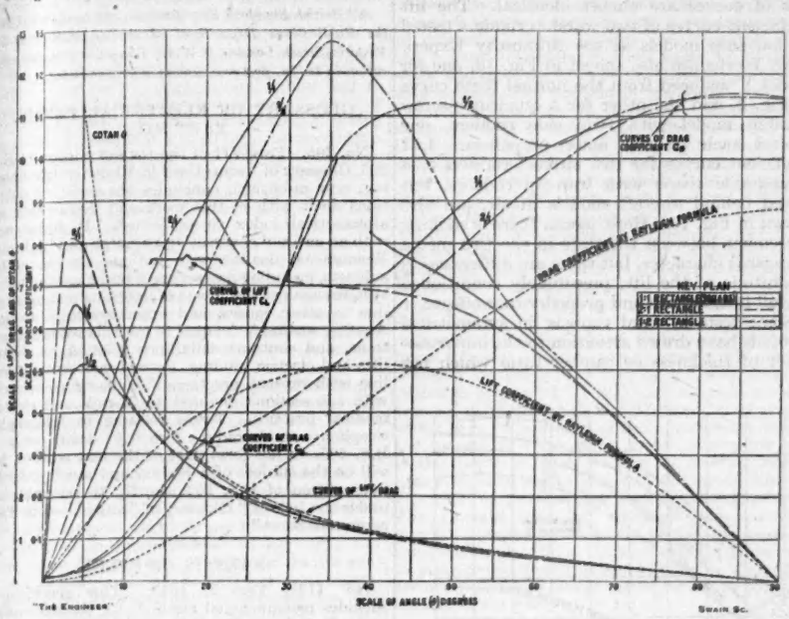



FIG. 7—*Forces on Rectangular and Square Planes*

Rayleigh's formula, an excess which might reasonably be assumed due to the suction on the back.

(*c*) *Intermediate Angles of Incidence from* 10 *deg. to* 60 *deg.*—This region comprises the most critical and remarkable features of comparison between the different planes. The initial steep rise of pressure with angle ceases and the curves approach their terminal character with a sudden breakdown. There are conspicuous differences between the planes in respect of the angle at which this breakdown or "burbling" occurs. In this region "the forces were at times unstable

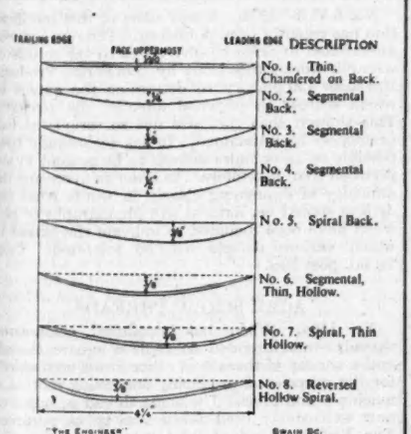



FIG. 8—*Blade Sections*

so that the curves are not always closely defined and in some cases it has been necessary to disjoin the curves." The "burbling" angle increases with decrease in aspect ratio, roughly from 12 deg. to 35 deg. As a result of this tendency the planes of larger aspect ratio which had considerably greater lift coefficient at small angles are the least satisfactory in the region of 20 deg. to 35 deg.

Thus, outline and proportions of rudder have an important influence. A deep, narrow rudder (*i.e.*, large aspect ratio) would be expected to be of advantage at comparatively small rudder angles, but if the effective rudder angle exceeds 15 deg. to 20 deg., then a square or circular shape is preferable. Unfortunately, a plane of more or less square outline is also subject to the "burbling" phenomenon, resulting in a sudden reduction of lift with increase of rudder angle beyond about 30 deg. This is, of course, one of the reasons for limiting the maximum rudder angle to 35 deg. It will, however, be shown later that smaller turning circles can be obtained with rudder angles of 45 deg., as compared with 35 deg. Comparison of the forces on the elliptical and rectangular planes of comparable proportions suggests that within limits shape of outline in itself is chiefly important in relation to aspect ratio. It is perhaps unnecessary to point out that the plane results have an application to other problems, including blade element analysis of propeller performance and design, the results for blades of rectangular outline and segmental and other sections in Figs. 9 and 11 being of particular interest in this respect. The shape of the sections of these blades is indicated in Fig. 8.

The curves include the ratio of lift to drag. For angles of incidence greater than about 15 deg., this ratio is almost equivalent to the cotangent of the angle of incidence, indicating that the resultant force is sensibly normal to the surface, the component along the surface being practically negligible. For angles of incidence between zero and 15 deg., the ratio varies substantially between the different planes, being greater with increase of aspect ratio. It is only in this region that there is any significant difference between the different planes. The importance of the bearing of this on steering is minimised because of the comparatively

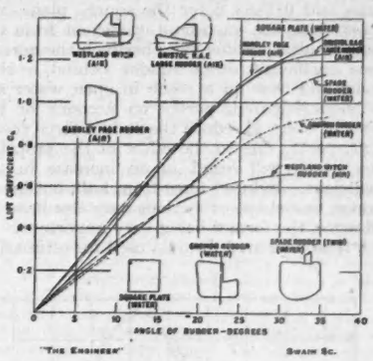



FIG. 10—*Curves of Lift Coefficient of Rudders of Warships and Aircraft*

small value of the force at the low angles of incidence at which the ratio is a maximum. An interesting feature of the blade tests is that the range of angle over which high lift to drag occurs is greatly extended, the best results being obtained with thin sections, although for angles of maximum lift the thicker sections show to slight advantage. Hollowing of the face impairs efficiency, but has the advantage of greater lift. Other characteristics of the blade sections are the positive lift at zero angle of incidence and greater force throughout, especially for the hollow blades.

It is shown above that Rayleigh's formula

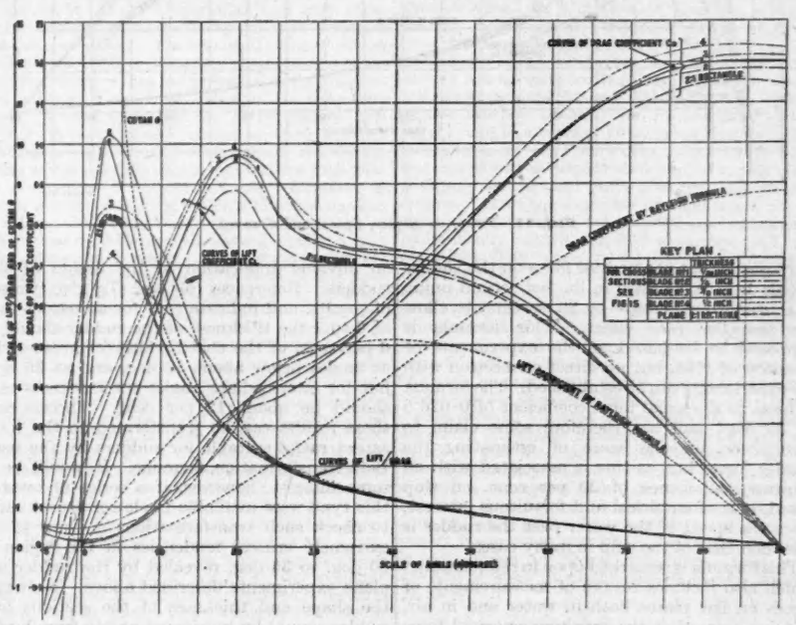



FIG. 9—*Forces on Blades of Segmental Section*

for the forces on the face of the plane with which the results were compared at the time the plane experiments were carried out gives results appreciably less than obtained by measurement. The lift coefficient, namely, $2\pi \sin \theta$, deduced from modern circulation theory for a plane of infinite aspect ratio, is well confirmed by the elliptic plane results of large aspect ratio for angles of incidence below

the "burbling" angle. The theoretical lift coefficient becomes progressively excessive at greater angles. Deductions from the circulation theory are referred to again in § 7 dealing with centre of pressure.

The normal rudder force coefficient at large angles is generally found to lie between about 0·024 θ and 0·032 θ for twin or quadruple-screw warships, with rudder on the middle line, the larger value relating to faster ships. If, however, the rudder is located abaft the propeller, the coefficient approaches 0·04 θ, which is regarded at Haslar as a conventional standard of comparison from the plane experiments in open water (*cf.* 0·0389 θ for the circular plane and 0·0463 θ for the square plane, the latter being the maximum coefficient from the plane results). Differences between the normal force coefficient on a rudder behind a ship model and that on a plane in open water are to be anticipated, partly on account of the effect of wake to reduce the rudder force coefficient, partly due to the effect of the propeller race which will result in an increase in the coefficient. Induced force from hull, outline of rudder, and shape of sections may also have an influence, the former being very important.

A time-honoured formula used for estimating purposes is that the normal force on the rudder equals 1·12 A V² sin θ in lb. feet second units. It is usual to increase V by 20 per cent. to allow for propeller race effect. This formula is supposed to be based on the experiments of Beaufoy of 1798, but no direct connection with his experiments can be established. The formula reduces to a normal force coefficient of 0·026 θ at 35 deg., and has therefore some claim to recognition on the score of estimating the rudder force, but as this is associated with an arbitrary allowance of 20 per cent. on ship speed, it is of empirical and fortuitous interest, since the speed of the water past the rudder is less than that of the ship in many cases.

This formula is remarked upon in reference (4),* which also includes results of measurements of forces on flat plates both in water and in air, and indicates that the maximum normal force is about 0·04 θ. More recent information concerning wind tunnel tests on various aircraft rudders is given in reference (5).† This report indicates that for an all-moving rudder free from shielding, the maximum lift coefficient $C_L$ may be as high as 1·2, but in general will be less on account of body screening. Thus 0·042 θ is the maximum normal force obtained in these tests in air. This report includes the results of experiments on fourteen shapes of rudder tested in the open. The maximum lift coefficient was obtained for an outline of trapezoidal form, the results for which are reproduced in Fig. 10 in comparison with those with the square plane reproduced from Fig. 6 as representative of the maximum lift coefficient obtained from experiments in water. The two sets of curves are almost identical. The lift coefficient curves of two warship rudders tested behind ship models at the Admiralty Experiment Works are also shown in Fig. 10, one for model Y deduced from the normal force curve in Fig. 3, and the other for a quadruple-screw warship model with twin side rudders, one behind each of the inner propellers. Lift coefficient curves for two aircraft rudders of a comparable shape with warship rudders, but tested behind aircraft models in air, are also shown in Fig. 10. Here, again, there is striking agreement between the tests in the two media as regards character, but there are differences in magnitude of the lift, presumably conditioned by full interference and propeller race effects.

Some tests in wind tunnels on symmetrical aerofoils have drawn attention to the important effect of thickness or camber ratio which has an obvious application to the design of ship rudders. References (6)* and (7)† give two sets of results, and indicate that for an aspect ratio of 6 to 1 the thickness of the rudder should be 6 per cent. of the chord width for greatest lift at angles below about 10 deg. and at 35 deg., but for intermediate angles the thickness ratio should be about 12 per cent. Theoretically these results can be transformed to the lower aspect ratios suitable for rudders by the usual Betz transformation formulæ. It would be of some interest, however, if a series of tests of this type were available for lower aspect ratios to check such transformations in view of the extremely critical tendencies in the region of 20 deg. to 35 deg. revealed by the rudder and plane experiments described above. Naturally the shape and thickness of the sections of a rudder cannot be considered purely from hydrodynamic considerations alone, since regard must be paid to strength of rudder and shape of after lines and profile of the hull. The results of model experiments on the fairly wide variations of thickness found practicable in warships do not suggest that the thickness or gradation of thickness over the depth of rudder should, within limits, be regarded as a very significant variable, from the point of view of efficient steering.

*(To be continued)*

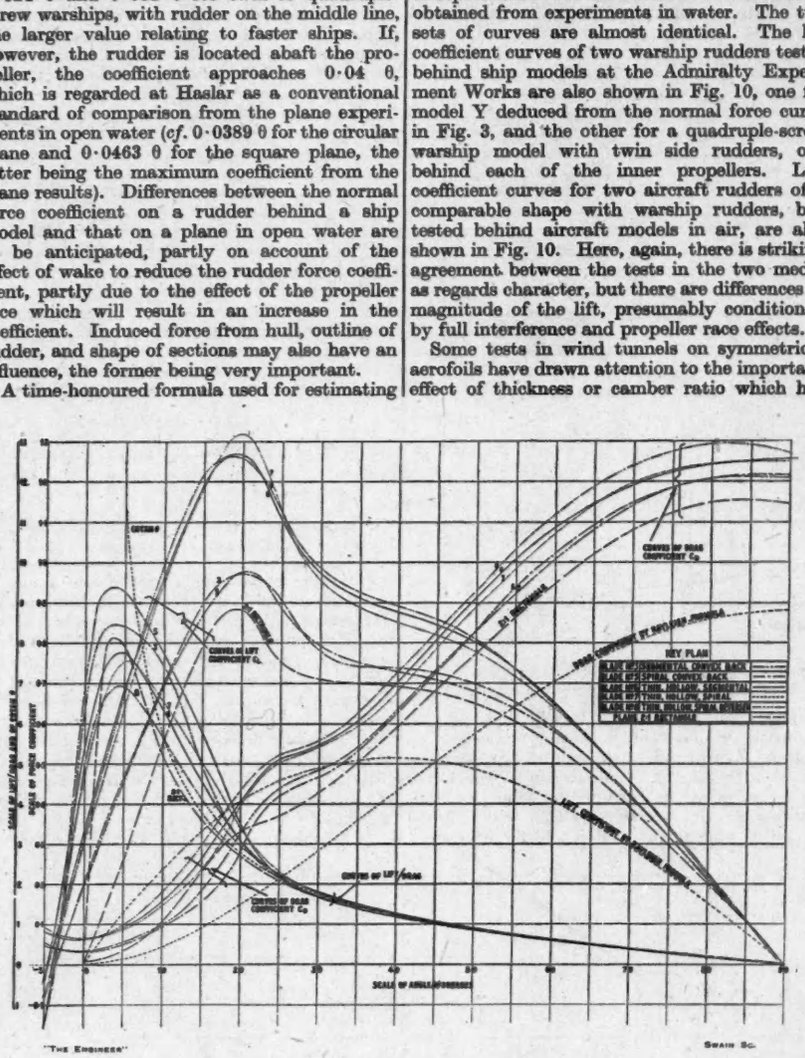



FIG. 11—*Forces on Blades, Spiral and Crescent*

* "Normal Pressure on Thin Moving Plates," A. W. Johns, I.N.A., 1904

† "Maximum Forces on Rudders," F. B. Bradfield, R. & M., 1932; A.R.C., 1930

* "Large-scale Characteristics of Aerofoils as Tested in the Variable Density Wind Tunnel," E. N. Jacobs and R. N. Anderson, N.A.C.A., 1930.

† "Rudder Force Curves," Fig. 38, page 285, *Werft Reederei Hafen*, September 15th, 1936.

## British Standards Institution

*All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1. The price of each specification is 2s. 3d. post free, unless otherwise stated.*

### GLOSSARY OF ELECTRICAL TERMS, PART VII

No. 205. Part VII of the revised edition of B.S. 205, Glossary of Terms Used in Electrical Engineering, now published, concludes the series of definitions dealt with in this work and leaves only the alphabetical index to be issued. It commences with an entirely new section on Surge and Lightning Phenomena, dealing with various aspects of the subjects, including protection of buildings and power systems against the effects of lightning and of surges due to other causes, and impulse-voltage testing. Another section is devoted to miscellaneous applications, and contains definitions relating to electric lifts and electric welding, revised and brought into line with present practice. The section concludes with sub-sections devoted to X-rays and electro-medical practice. Terms relating to telegraphy, telephony, and radio, formerly dealt with in B.S. 205, do not form part of the new edition, but will be the subject of a revised and much enlarged new edition of B.S. 204, shortly to be published under the title of "Glossary of Terms Used in Telecommunication."

### ANALYSIS OF STEEL

No. 1121, Part 1, 1943. This specification includes recommended methods for the determination of sulphur, phosphorus, and lead in steel. It forms the first instalment of a programme of work for the preparation of standard methods for the analysis of steel generally. As sulphur and phosphorus are the two elements which are specified more frequently than any other, attention has been given to them first of all. The determination of lead was included, as it was a point of considerable importance at the present time in the development of leaded steels. Work is being continued in the preparation of methods for the determination of carbon and manganese and will ultimately cover all alloying elements. The experimental work is being carried out by a Committee of the Iron and Steel Institute, and very close agreement was obtained in the results of the various investigators who tried out the methods for sulphur, phosphorus, and lead.

### HIGH-STRENGTH PLYWOOD FOR AIRCRAFT

No. 6 V. 3—1943. A new issue of this specification has recently been published. The revision was undertaken in order to give effect to the results of research work carried out by the Forest Products Research Laboratory to determine the extent to which defects in plywood affected the strength. This showed that they are not so serious as had previously been assumed. It has accordingly been possible to allow more defects to be present in the plywood than heretofore. In order to overcome the difficulty of expressing clearly in words what the defects should be, natural size photographs of plywood have been included to indicate the extent to which various defects will be tolerated. Price 1s. 3d. post free.

### ACME SCREW THREADS

No. 1104. When first introduced, acme screw threads were intended to replace square threads and a variety of threads of other forms used chiefly for the purpose of producing traversing motion in machines and tools. The acme thread is, however, now extensively used for a variety of purposes. The British Standard relates to the design and dimensions of acme single-start threads intended primarily for translating screws. The design has been chosen with the dual purpose of meeting the varied needs of users to the greatest possible extent and at the same time establishing a product which can be economically produced. The basic sizes and tolerances laid down in this British Standard are identical with those standardised in the U.S.A., and will provide strict dimensional interchangeability with American products. The specification defines the basic form of thread and gives the detailed limits and tolerances for a single class of fit for acme threads from ¼in. to 5in. nominal diameter. An appendix to the specification gives a recommended system of gauges for controlling the production of acme screws and nuts. Price 2s. net post free.

# Markets, Notes and News

**The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer.**

### Iron and Steel in the United States

The iron and steel situation in the United States does not appear to have returned to the comparatively smooth running which characterised the situation before the coal strike. In the middle of July the number of blast-furnaces scheduled to resume operations were unable to do so owing to renewed "outlaw" strikes at coal mines and to some interruptions of supplies of coke. At that date, writes our American correspondent, about twenty-five United States Steel Corporation's blast-furnaces in the Pittsburgh area were then in operation, whilst in the Ohio district the operations of six furnaces were slowed down to 75 per cent. of the normal output. It was expected that six furnaces would resume operation shortly. In the Birmingham area twenty of the twenty-one furnaces are undergoing repairs and are expected to resume shortly. The Government agencies are diverting coal from the output of Government-controlled mines to districts where there is a scarcity. In Canada eleven out of the twelve blast-furnaces are in full operation. Fuel difficulties, however, do not affect the scrap market, and in July there was strong buying of heavy grade scrap at Pittsburgh. Consumers require the metal to supplement the reduced output of molten pig metal for open-hearth use as a result of the coal stoppage. The production of steel is maintained at a good rate and averaged 97 per cent. early in July, equivalent to an estimated 1,679,700 tons of ingots weekly. The production varied slightly in the different districts. Pittsburgh output was at 99 per cent. of capacity, Chicago 99·5 per cent., Detroit 98 per cent., and Youngstown 97 per cent. The United States production in June totalled 7,027,101 tons of ingots, an average of 94·6 per cent. of capacity for that month. This compared with a production in May of 7,545,379 tons and in April of 7,374,154 tons. In June the deliveries of finished steel by subsidiaries of the United States Steel Corporation declined by 153,880 tons to 1,552,663 tons. In May deliveries were 1,706,543 tons. Plate mill output fell off in June to 1,056,000 tons, as a result of the coal stoppage. The previous month it was 1,114,920 tons, the decline totalling 58,835 tons.

### The Pig Iron Market

Although there is a steady volume of business passing in all descriptions of pig iron, it is not so large as that which was transacted in the early part of the year. Many consumers have placed their allocations and producers have orders which in many cases cover their whole production until almost the end of the year. There is a feeling abroad in the market that the arrival of a high-grade ore from Africa, several cargoes of which are known to have reached this country, is likely to have a considerable effect on the pig iron position. The "make" of hematite is likely to be increased in due course, and production of low-phosphoric and refined pig iron will expand. For a long time consumers of hematite have used refined and low-phosphoric iron as substitutes, owing to the tightness of the hematite position. The increased output of hematite, therefore, should result in a lesser demand for these qualities, and thus increase the quantities available. It will, of course, be an appreciable time before the increased quantities of high-grade ore which have become available will reach the market in the form of pig iron, and consumers of hematite are anxiously awaiting that time. The output of high-phosphoric pig iron is on a considerable scale, and consumers find no difficulty in satisfying their full requirements. A fair amount is now reaching the light castings industry, but there are many works in this industry which are not fully employed. The heavy requirements of the steel makers for basic iron are being met, and they are receiving regular deliveries. There is also a steady business passing in forge iron.

### The Midlands and South Wales

All Midland iron and steel works are well supplied with specifications which will keep them working at maximum pressure for the next few months. Output may be slightly affected by the holidays, which will be taken in August, and will commence with the August Bank Holiday break. Where possible, however, arrangements have been made to stagger the holidays, although this is not a popular method, and its efficiency in maintaining production is doubted by many. In cases, however, where repairs to plant which has been running at high pressure for over a year are urgently needed, the works will close down for a brief spell. In many cases also the labour force needs a rest from the continuous strain of working at the rate called for during the past twelve months. In a number of sections consumers have built up stocks during recent weeks, and this has resulted in some easing in the pressure for delivery. Generally speaking, however, the consuming works are not in a position in which they can dispense with a continuous flow of deliveries. Plate makers are congested with the amount of orders on their books for priority work, and there seems to be no relief in sight in this department. The position in the sheet section of the trade, however, is different. Makers have plenty of work in hand, principally on account of Government Departments, and will be busy until much later in the year. The relaxation in the sheet trade is noticeable in the considerable diminution in the flow of new orders, which are not sufficient to take the place of those which are worked off. Whilst there is a considerable demand for joists and sections, this is concentrated principally upon the lighter sizes, and there is a comparatively poor request for heavy kinds. Makers of the latter are generally able to give promise of comparatively early delivery on new business. The demand for colliery steel is active. Bars, arches, and light rails are in demand, and the requirements of the mining industry are being fully met by the steel makers. Although comparatively little new business is being transacted by the South Wales iron and steel works, which have booked most of their production during the current delivery period, great activity prevails in the industry. Steel makers are meeting with a heavy demand for billets, and the production of this class of material has been increased latterly. The tinplate industry, although comparatively poorly employed, is taking up its full allocation of sheet and tinplate bars. It is not easy for consumers to place new orders for sheets, as few of the works are in a position to accept orders for delivery before the end of the year.

### The North-East Coast and Yorkshire

Production by the iron and steel works on the North-East Coast is kept at a very high level. Even on this coast surprise is felt that it has been possible, in spite of all the wartime difficulties, to maintain production outputs. The hard work involved, however, has had its effect both upon employees and plant, and some relaxation for the labour force is advisable. Staggered holidays have been arranged at many of the works, but there was no general stoppage on the Bank Holiday. Most of the plants remained in operation, and only those works at which considerable repairs were necessary closed down entirely. The immediate outlook shows no likelihood of there being any relaxation from the intensive pressure that has prevailed in the iron and steel industry for so long. Most of the works are heavily booked until the end of September, and some are in no position to accept any large amount of business until the end of the year. All the re-rolling works are fully employed, and are maintaining production at capacity levels. Supplies of billets, blooms, and slabs are on a larger scale than for a long time, but even so the re-rollers have to make use of defectives, shell discard, steel and crop ends. They are, however, receiving steady weekly deliveries under the authority of the iron and steel control and also substantial quantities of material released from stocks of imported American semis. Few of the re-rolling works are in a position to accept orders for delivery before late in the autumn. In addition to producing large tonnages of small bars, sections, and strip, they are helping to meet the demand for plates by turning out good tonnages of light plates on the sheet mills. A substantial volume of business is passing in alloy steel and joists and sections, but there is a comparatively poor request for heavy joists and sections, and most of the producers of this class of material are able to give delivery at comparatively short notice. The Yorkshire iron and steel industry is operating at capacity. The production of basic steel is on a particularly heavy scale, and the whole output passes rapidly into consumption, whilst all the available plant is engaged in meeting the enormous demand for acid carbon steel. The volume of business in alloy steel has declined somewhat and shows a tendency to concentrate on the cheaper descriptions. There is practically no unemployed plant amongst the forges and press shops.

### Scotland and the North

The annual Glasgow Fair holidays, which commenced on July 16th, did not greatly affect the steel position in Scotland. Advantage was taken of the closing down of works to carry out repairs which were badly needed owing to the unremitting work which they had been called upon to undertake for a long time. Many of the consuming works were in the same position, so far as necessary repairs were concerned, as the iron and steel works, but in some cases the producing works ceased operations a week earlier than usual, so that by staggering the holidays deliveries were not completely cut off to those consumers who remained in operation. The situation has changed little for a long time. Recently the demand for shell steel has declined to some extent, whilst there is a comparatively poor demand for heavy joists and sections. A large volume of business, however, is passing in small bars and small sections, and most of the works producing this class of material have enough orders on their books to keep them busy until the end of September. Large bars over 3in. in diameter are meeting with a steady demand from the engineering industry, but a comparatively small business is being transacted in heavy joists. The outstanding demand, however, in finished steel is for plates. The shipyards have a big programme of construction of naval and merchant shipping in hand, and their plate requirements seem to be inexhaustible. In addition, locomotive builders, tank makers, and heavy engineers are taking up big supplies. There is a steady demand for iron bars and lately consumers requiring steel bars have diverted their orders to the iron bar mills which can give earlier delivery. The Lancashire steel market is extremely active, but holiday conditions have to a certain extent affected the situation, since a number of consuming works as well as producing works have found it necessary to close down for a brief holiday. The call for medium heavy plates is unrelaxed, and amongst the active buyers of this material are electrical engineers, boilermakers, and locomotive builders. The demand from the engineering industry, particularly for steel bars of the heavier sizes, is well maintained, and there is also an active business passing in bright drawn steel bars. Consumers are taking up considerable quantities of nickel and other alloy steels, and there is a big volume of inquiry on the market. On the North-West Coast the iron and steel works are operating at capacity and are largely upon Government work.

### Iron and Steel Scrap

The iron and steel scrap position in Great Britain is slow to change, although minor movements have been noticeable during the last few weeks. Generally speaking, however, the demand throughout the country is steady, although there is a stronger request for better grades than for the cheaper sorts. It is noticeable that the demand for any kind tends to strengthen as the material gets into shorter supply, and as the quantities of good heavy scrap are by no means plentiful, consumers are showing an increasing desire to cover their requirements and accumulate reserves. Other grades of scrap, however, are in moderately good supply, and in a number of cases the dealers find a difficulty in moving their stocks. Good heavy mild steel scrap cut to furnace sizes and to cupola sizes is eagerly sought, and quick delivery is frequently desired. There is a moderate demand which shows signs of improvement for bundled steel scrap and hydraulically compressed steel shearings. All the quantities that come on the market are quickly taken up, and the demand is sufficient to absorb a larger tonnage than seems to be available. There is a steady trade passing in mild steel turnings. The good heavy qualities are in brisk request from consumers, and the "chipped" qualities are receiving a fair amount of attention. A steady volume of business is passing in mixed wrought iron and steel scrap for basic steel furnaces. There is a fairly strong demand for good heavy material, but users appear to have large quantities of the lighter kind in hand, and these are rather difficult to move. The tight supply position of heavy material has created a stronger demand for compressed basic bundles. Consumers are active buyers of heavy cast iron in large pieces and furnace sizes, but the supply is somewhat restricted. Light cast iron also is not offered in liberal quantities. Cast iron machinery scrap in cupola sizes is eagerly sought by users.

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THE DAMS OF JAPAN.—That Japan would be vulnerable to attacks on its dams and hydro-electric plants is the opinion of Dr. W. Monroe White, hydraulic engineer, formerly manager of Allis-Chalmers, Milwaukee, Wis., hydraulic department, who supervised the installation of equipment in eight such Japanese plants. If American bombers could get bases close enough to strike, they would have access to about 100 such targets, and crippling them would hinder Japan's war effort at least nine months, and possibly for the duration of the war. Lack of coal in Japan has made water power a first essential.

# Notes and Memoranda

## Rail and Road

CANADA INITIATES RUBBER PRODUCTION.—The first synthetic rubber manufacturing plant in the British Empire was placed in full-scale operation in Montreal recently by a subsidiary of the Dominion Rubber Company, Ltd. It will produce "Thiokol," one of the five commercial types of synthetic rubber, and the complete output of the plant has been placed at the disposal of the Dominion Government.

BUDAPEST'S UNDERGROUND RAILWAY.—Consequent on satisfactory geological drillings, the construction of new lines for the Budapest Underground Railway is likely to be among the immediate post-war contracts to be undertaken. The length of the existing underground line in Budapest is not more than 2¼ miles. The four proposed new lines will connect the various Budapest main line railway stations, and will comprise a system with a route length of some 18 miles.

RENAMING THE ALCAN HIGHWAY.—Once more the name of the Alcan road is under review, and perhaps for the last time. The U.S. Army North-West Service Command has announced the abandonment of the name "Alcan," and henceforth the 1600-mile road will be officially known as "The Alaska Military Highway." This further change of name will involve a big repaint job. The name "Alcan" painted on hundreds of lorries which ply up and down the highway will now have to be redone.

FUEL ECONOMY EXHIBITION.—The British railways have lent their exhibition coach to the Ministry of Fuel and Power for a tour of the country. A Fuel Economy Exhibition has been fitted into the coach by the Ministry of Information, and it has paid two calls to Scottish stations—Aberdeen Joint Station, July 26th, 27th, and 28th, and Waverley Station, Edinburgh, August 2nd, 3rd, and 4th. The exhibition is a miniature replica of the principal exhibits from the Fuel Exhibition held at Dorland Hall, London.

STEAM POWER FROM ELECTRICITY.—The extreme shortage of coal in Switzerland has led the railways to equip a few steam shunting locomotives with means for electrically heating their boilers. Tubular elements, provided on both sides of the boiler, are connected with the secondary windings of two oil-cooled transformers which have air-cooled radiators in the oil circuit. A pantograph of normal type is mounted on the roof of the cab. The conversion of the engines was carried out in the Swiss Federal Railway workshops at Yverdon. The engines work, but the plan is admittedly uneconomical.

MAGNETIC NAIL PICKERS.—The State Highway Authority of Texas has had in use for some time two magnetic nail pickers, which have retrieved more than 84 tons of nails, bolts, nuts, and other metal fragments gathered from highways during the last two years. The magnetic pick-up device is suspended from the rear of a 1½-ton lorry. Electricity is supplied from a 125-volt, 32-ampere, D.C. generator, belt driven from a four-cylinder auxiliary engine. Both of these units are mounted on the lorry along with the magnets. With the magnet in operation and suspended about 4in. from the ground, the lorry travels from 5 to 8 miles an hour. After the magnet has picked up a quantity of metal, a canvas stretcher is placed beneath it. When the current is turned off the metal pieces fall on the canvas, thus permitting easy removal.

## Air and Water

THE "NORMANDIE."—Admiral E. L. Cochrane, of the U.S. Navy, has informed a House Appropriations Sub-Committee that salvage operations in New York on the burned and capsized "Lafayette," the former "Normandie," will be completed and the ship floated by the coming autumn.

PROPOSED KIMBERLEY AIRPORT.—Kimberley's potentialities as a post-war airport for civil aviation are being studied in South African circles. Among many advantages—apart from its geographical position—Kimberley boasts a symmetrical landing area, large and level. It is on the shortest route from the Rand to Cape Town, and claims to be the true centre of Southern Africa, including South-West Africa, Angola, and the Belgian Congo.

JAPAN PLANNING CANALS IN CHINA.—Japan is reported to be contemplating the construction of a 300-mile canal to connect the Hwangho River in northern China with the Imperial Canal in Shantung Province. The canal is to begin near Cheng, in Honan Province. In addition to easing the transport problem in the provinces concerned, the canal should reduce the yearly recurrence of flooding by the lower Hwangho. Nor is this all the current evidence that Japan expects to stay in China. Another report hints at a tunnel to be built under the Yangtze River near Nanking, to connect the railway systems north and south thereof.

RADIO IN SOUTH AFRICA.—Bloemfontein and Kimberley are two of the four centres selected for the establishment of new long-distance wireless stations in South Africa. In the railway loan estimates that were adopte by Parliament, £8366 is provided for the erection of the necessary equipment in Bloemfontein and £7850 for Kimberley.

WOODEN BARGES NOT OIL-TIGHT.—Because wooden barges cannot carry light oils, the Office of Defence Transportation reports that construction of 195 of the scheduled 500 wooden barges has been cancelled and will be balanced by a fleet of 168 all-steel welded barges capable of handling both light and heavy oils. The new fleet will operate on the Mississippi and Ohio rivers to increase the transportation of oil to the eastern seaboard.

CANADA MAY PROVIDE U.S.A. WITH AN AIRPORT.—Negotiations are afoot for the construction in the near future of a 10-million-dollar airport near Namao, 7 miles north of Edmonton, to fill the wartime needs of the U.S. Government. According to some reports, the United States will pay for the airport, while others say that the Canadian Government will build it and own the site, but that supplementary buildings and equipment will be paid for by the United States.

AMERICAN SHIPS FOR BRITAIN.—Speaking in the House of Commons on Tuesday, August 3rd, the Prime Minister read a letter from President Roosevelt announcing his decision to transfer to the British flag for temporary wartime duties during each of the next ten months a minimum of fifteen merchant ships. He had further suggested that this number should be increased to twenty. Mr. Churchill expressed the satisfaction of the House and the country with this generous offer, and stated that the Canadian Government was making a similar arrangement with regard to ships built in Canada.

## Miscellanea

STEEL PRODUCTION IN ONTARIO.—There is some prospect of the establishment of a steel production industry in the Port Arthur and Fort William area. This was suggested recently by the Chairman of the Ontario Hydro-Electric Power Commission, as a result of the combination of iron ore production and cheap hydro-electric power.

INSTITUTION OF STRUCTURAL ENGINEERS.—Results of the January examinations of the Institution of Structural Engineers, held at prisoner-of-war camps in Germany, have just been announced. The number of candidates was ten. Two passed the graduateship examination and seven the associate membership, making a total of nine successes.

ROOFING MATERIAL FROM RAGS.—A Chicago concern has devised a method by which rags and resin can be combined to make a war emergency building material. Introduced as "corrugated asphalt siding," it replaces corrugated steel sheets. The siding consists of two sheets of heavy felt saturated with a resino-bituminous compound, bound together with a high melting point asphalt adhesive and corrugated under high pressure. Finished sheets are hard, rigid, light in weight, and moistureproof.

CHROMIUM FROM RHODESIA.—Up to 1938 Russia held the record for chromite production, with Turkey next and Rhodesia third. For 1939 and 1940 the Russian figures are not available, but Rhodesia, with 300,000 metric tons, was easily first. To-day Southern Rhodesia is reputed to be the world's largest producer of chromite, and in 1941 is estimated to have supplied about 45 per cent. of the world's total production. The deposits are found in the Gwelo, Lomagundi, Victoria, and Hartley districts, with the first-named the chief producing area.

DIAMOND CUTTING FOR TOOLS.—In an informative article on diamond set tools, by Mr. C. H. Sloan, and published in *The South African Mining and Engineering Journal*, emphasis is laid on the importance of the orientation of the crystallographic directions of the diamond with respect to the cutting surface of the tool. A basic consideration in cutting a gem diamond is obtaining the maximum weight in the finished stone. Most diamond crystals are distorted and the orientation of the cut stone is determined by taking into consideration the shape of the rough crystal. The strong tendency to carry this same policy over into the cutting of diamond tools and the reluctance to sacrifice weight for proper orientation accounts for some of the poorest diamond tools. The failure of the tools is then blamed upon the diamond rather than upon improper orientation. If the cutter has available a large inventory of rough stones from which to select a crystal for a specified tool, he can combine proper orientation with a minimum loss of weight.

## Personal and Business

MR. NORMAN GWYNNE ALLEN has been appointed a director of W. H. Allen, Sons and Co., Ltd., Bedford.

MR. J. SIMPSON has resigned his position as manager of the soot blower department of Hopkinsons, Ltd.

PATERSON HUGHES ENGINEERING COMPANY, Ltd., has transferred its London Office to Bedford House, Bedford Street, Strand, W.C.2 (telephone, Temple Bar 7274).

REAR-ADMIRAL EMORY S. LAND, Chairman of the United States Maritime Commission, has been elected an Honorary Fellow of the North-East Coast Institution of Engineers and Shipbuilders.

THE MINISTER OF WAR TRANSPORT has appointed Mr. W. Guy Ropner to be his representative in Canada. Mr. Ropner is at present Deputy Director of the Ship Management Division of the Ministry.

MR. R. POLLARD, chief engineer at Redfern's Rubber Works, Ltd., Hyde, for the past twenty-two years, has decided to retire from that position owing to ill-health. He will not completely sever his connection with the company.

DR. K. G. FENELON, Director of the Department of Industrial Administration, Manchester College of Technology, has been appointed general secretary of the Institution of Production Engineers, in succession to the late Mr. Richard Hazelton.

MR. R. A. RIDDLES has been released by the Minister of Supply from his post of Deputy Director-General for Royal Engineer Equipment at the request of the L.M.S. Railway. He is being succeeded by Mr. R. A. Davis, formerly Deputy Director-General with the Ministry of Supply Mission in Washington. Mr. Riddles will continue for the time being to be available to advise Mr. Davis on questions of locomotive design.

THE MINISTRY OF SUPPLY announces that Major J. M. Campbell has asked to be relieved from his duties as Joint Deputy Controller for Raw Materials in the Iron and Steel Control. Mr. C. R. Wheeler, who has been Joint Deputy Controller with Major Campbell, will continue as Deputy Controller for Raw Materials. The Iron and Steel Controller has accepted the resignation of Mr. T. H. Summerson as Director for Steel Castings, whose release has been applied for by his company. He will be succeeded by Mr. H. Humphries, who will also continue his existing office as Director for Steel Forgings and Tyres, Wheels, and Axles. Mr. P. C. Fassette will continue as Technical Director (Castings) and Mr. H. P. R. Scott as Deputy Director for Steel Castings.

DEATH OF MR. JOHN F. STEVENS.—Mr. John F. Stevens, the engineer whose organising ability paved the way for successful completion of the Panama Canal under the direction of Colonel George W. Goethals, died at his home in Southern Pines, N.C., on June 2nd, in his ninetieth year. Because his work at Panama was overshadowed by the equally noteworthy and more spectacular work of Colonel Goethals, Mr. Stevens' name probably will be best known for his work as a pioneer railway builder. His work in that field reached high points in his discovery of Marias Pass, the route by which the Great Northern got through the Rocky Mountains on its way to the Pacific Coast, and his subsequent discovery of the pass through the Cascade Range that now bears his name.

## Forthcoming Engagements

*Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the* TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

### Institution of Electrical Engineers

*Sunday, Aug. 8th.*—N.E. STUDENTS' SECTION: Visit to Durham Cables, Ltd. 3 p.m.

### Junior Institution of Engineers

*Saturday, Aug. 21st.*—MIDLAND SECTION: Visit to the Birmingham City Transport repair works. 2.30 p.m.